



Artificial Intelligence for Factories of Future

Presentation of Case Solutions

Harsh Sinha, Dhekane Eeshan Gunesh, Animesh Shastry

Presentation for Campus Round—

Group Team ID : 3948

Team Mentor : Sugam Kumar



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Robots and AI for Factories of Future

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Topics

Online Tracking of Vehicle Movement

Online Tracking of People Movement within Factory Premises

Online Tracking of Material Stock Status

Artificial Intelligence/Augmented Reality Applications

Low-Cost Robotics to Replace End-of-Line Manual Work

Online Condition Based Monitoring (CBM) for Critical Equipment

Camera to Track Human Compliance/Violation to SOP



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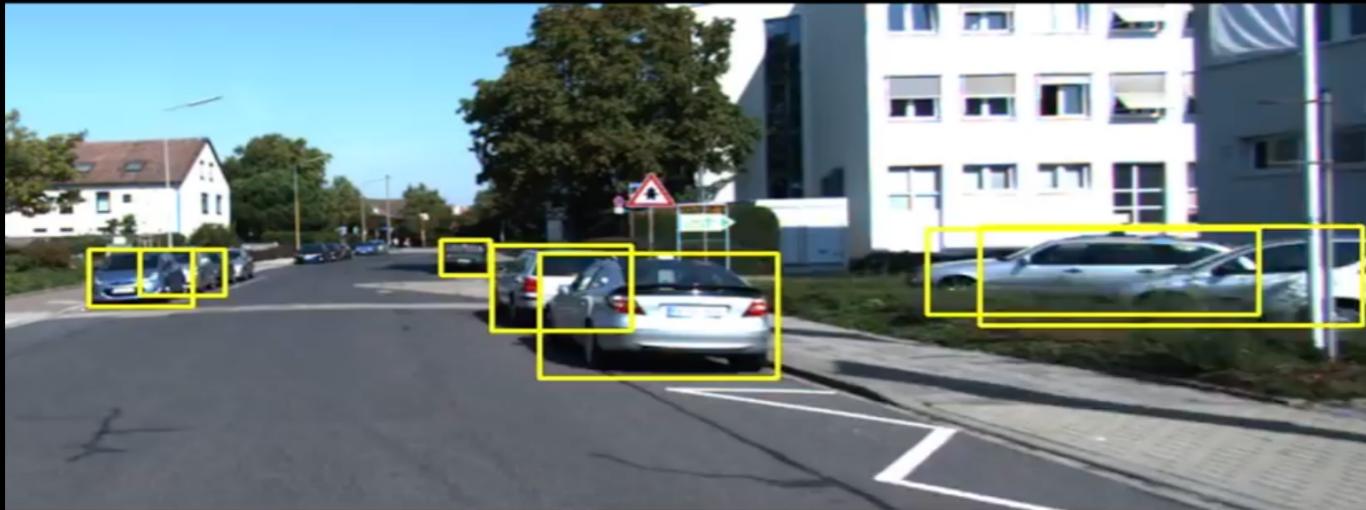
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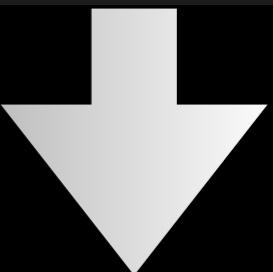


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Vehicle/Person Tracking



**Deep Learning
with
Convolutional
Neural Nets**



**Simultaneous
Multi-Object
Detection**

Detection-Based Tracking



Online Tracking of Vehicle Movement

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Online Material Stock Tracking



Sennheiser
G4ME SERIES
G4ME ZERO
Gaming
Headset
Microphone



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QR Code Tracking & Management, blog.qrd.by/2016/03/07/print-batch-qr-codes-on-labels/
Sennheiser, Sennheiser G4ME SERIES G4ME ZERO Gaming Headset Microphone

Image Credits



Tracking Stock Status with QR



Navigate

Scan

Update

Robots-Based Warehouse Inventory Management



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Locus Robotics Autonomous Robots, Simply Pick Faster with Autonomous Robots in the Warehouse
QR Code, Mr. Robot TV Series Easter Eggs
DENSO Robotics, DENSO Robotics - Robot Uses QR Code® Scanner

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Online Tracking of Vehicle Movement

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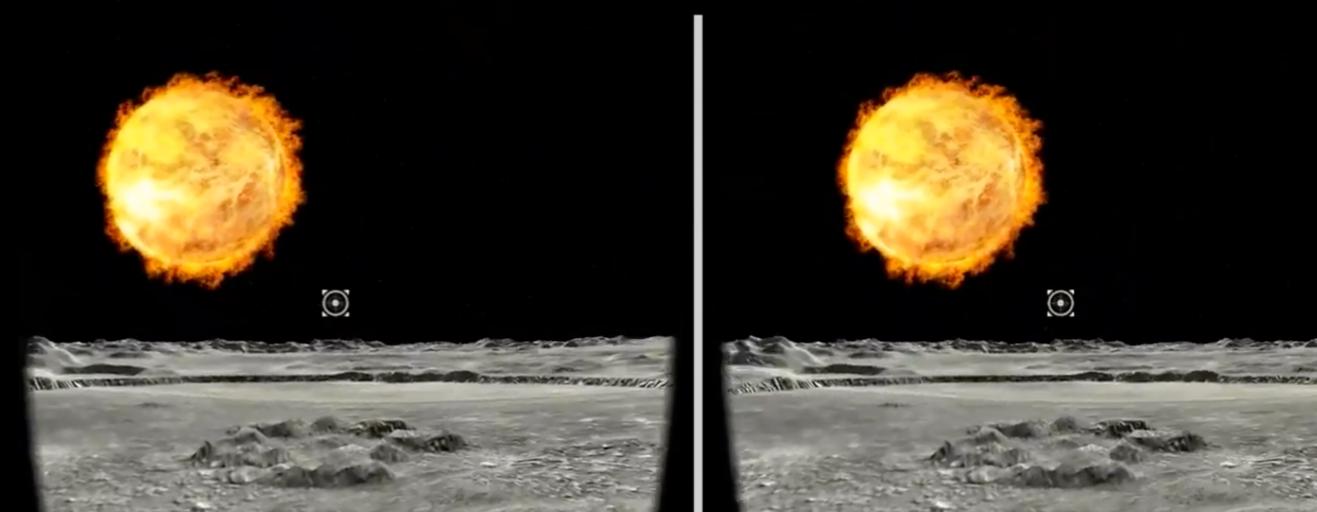
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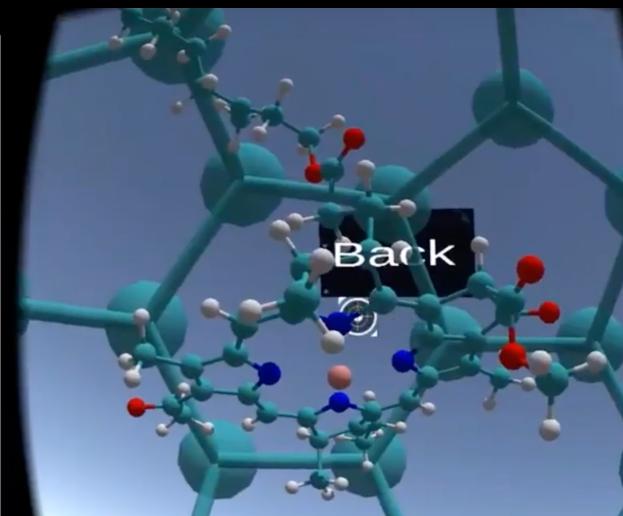
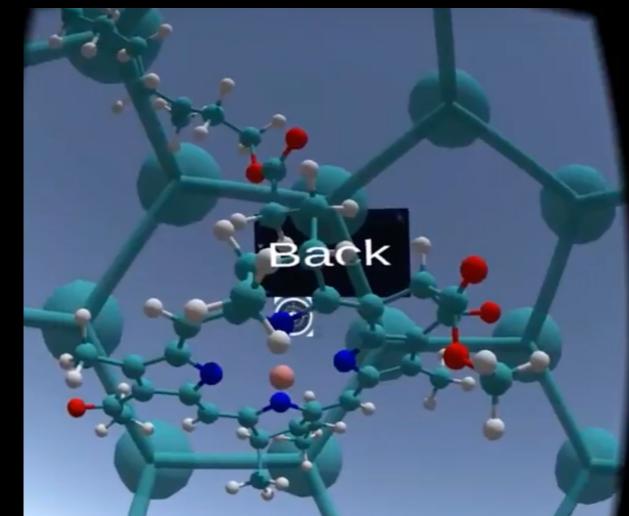
AR/VR Applications



AR



VR



AR/VR Applications Are Easy-to-Build!!



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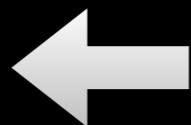
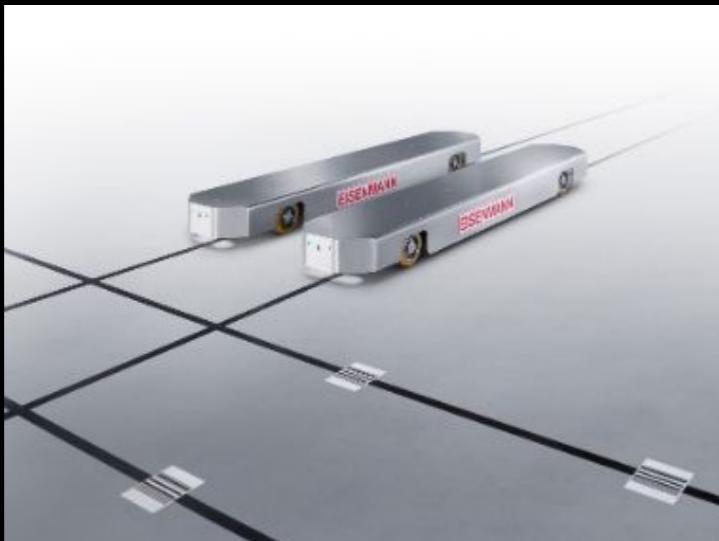
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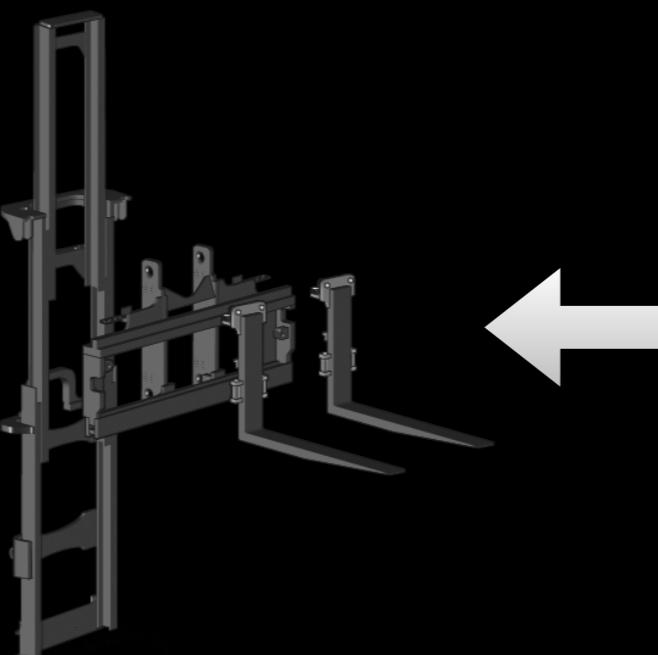
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Two-Component System



Robotic Forks



Lifting Module



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Image Credits

Eisenmann Mover, Robotic Fork
Toucan Lift Equipments, Lifting Module



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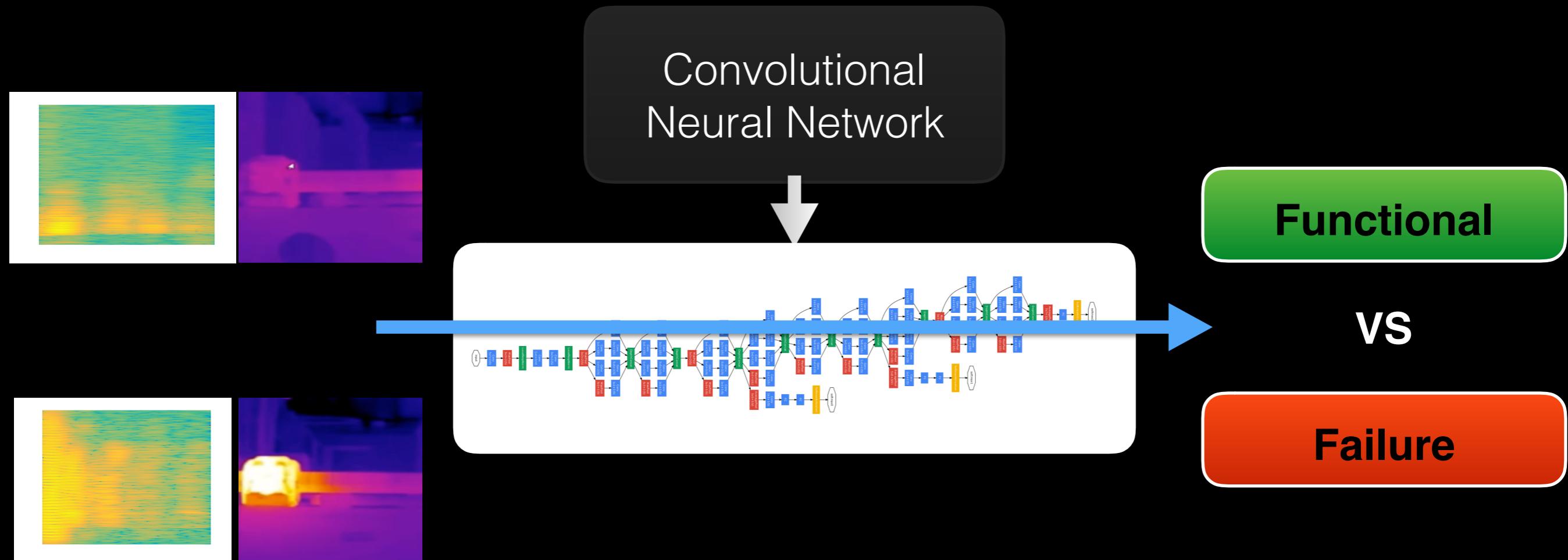
Camera to Track Human Compliance/Violation to SOP



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Deep CNN-based Detection



Train CNNs to Predict from the Monitoring Signals the Condition of Systems



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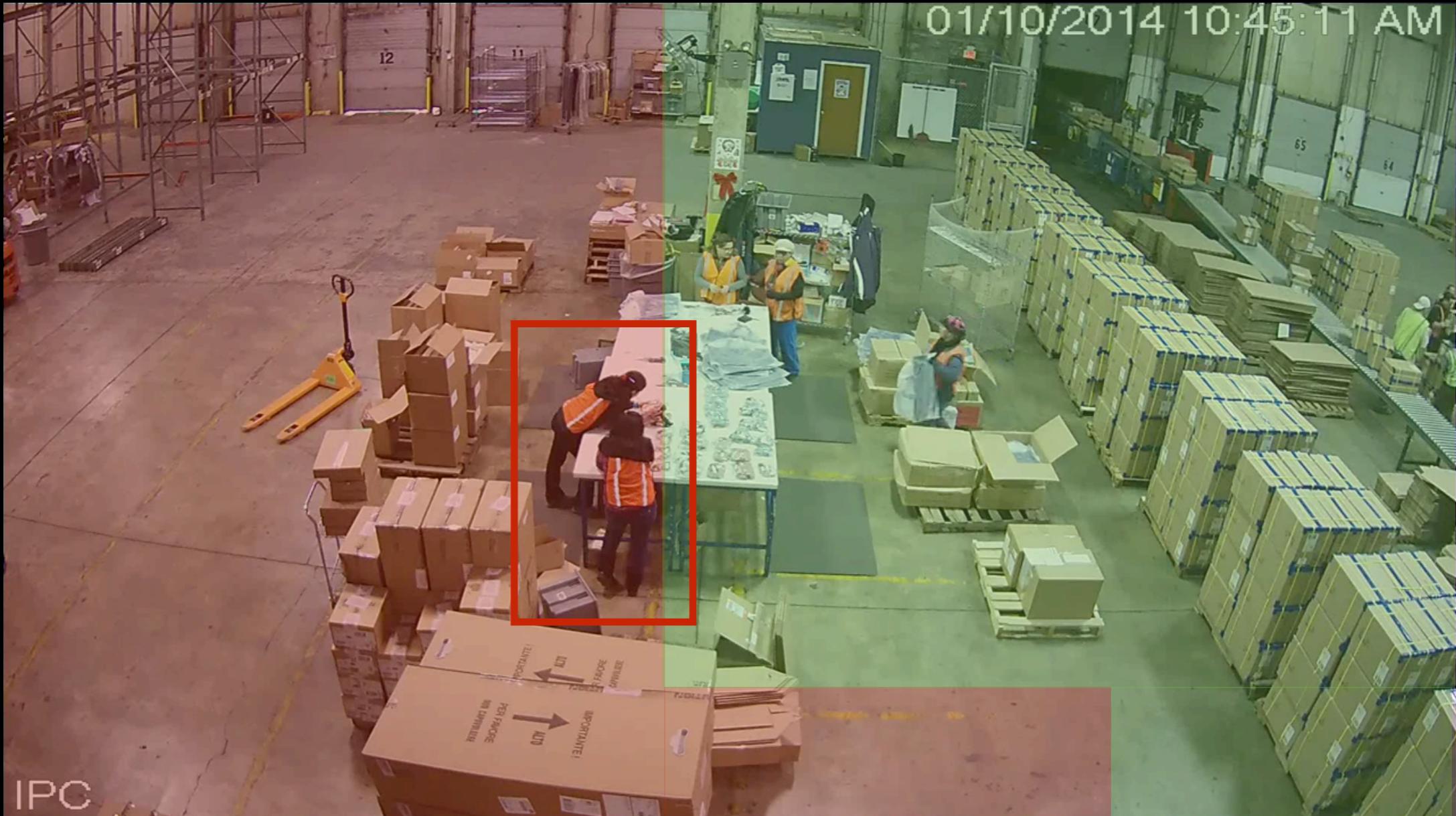
Camera to Track Human Compliance/Violation to SOP



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Human Compliance/Violation to SOP



Can Be Mounted as Problem of Detection and Categorisation



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Video Credits

Matt Caracino, Example of Hi-Definition Video Surveillance of a Factory Floor



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Tracking Stock Status with QR



QR Codes Are Already Present on Boxes ...



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Tracking Stock Status with QR



Sennheiser
G4ME SERIES
G4ME ZERO
Gaming
Headset
Microphone



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QR Code Tracking & Management, blog.qrd.by/2016/03/07/print-batch-qr-codes-on-labels/
Sennheiser, Sennheiser G4ME SERIES G4ME ZERO Gaming Headset Microphone

Image Credits



Tracking Stock Status with QR



Navigate

Navigate in the Warehouse/Factory



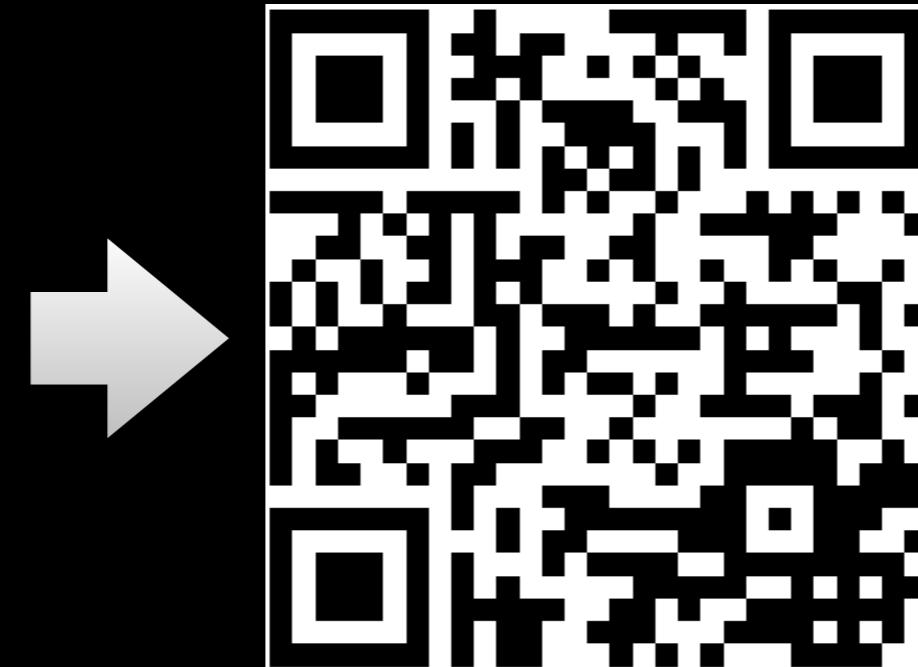
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Image Credits



Tracking Stock Status with QR



Navigate

Scan

Scan the QR Codes on Storage Boxes

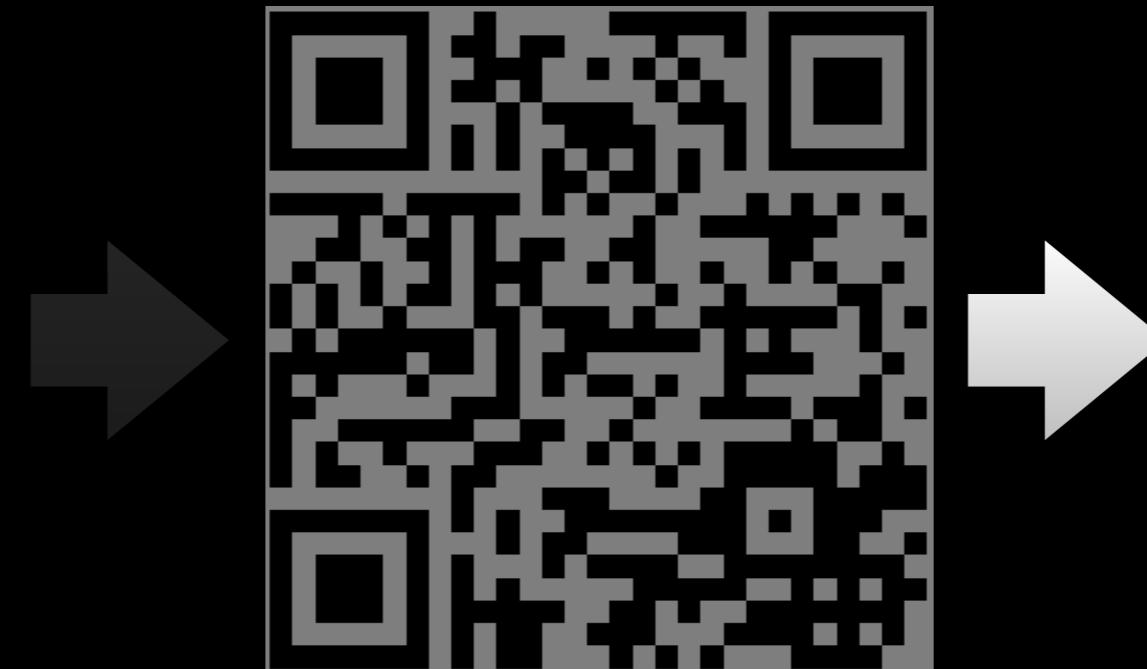


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Image Credits
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QR Code, Mr. Robot TV Series Easter Eggs



Tracking Stock Status with QR



Navigate

Scan

Update

Update the Inventory



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Tracking Stock Status with QR



Navigate

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Update

Robots-Based Warehouse Inventory Management



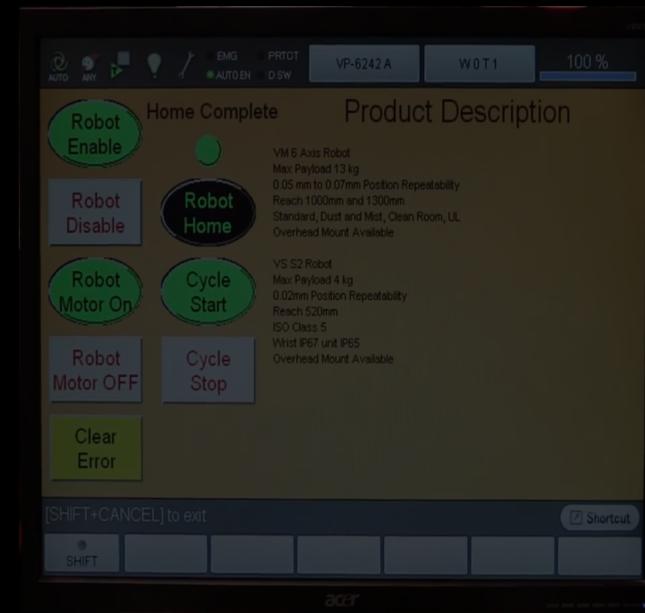
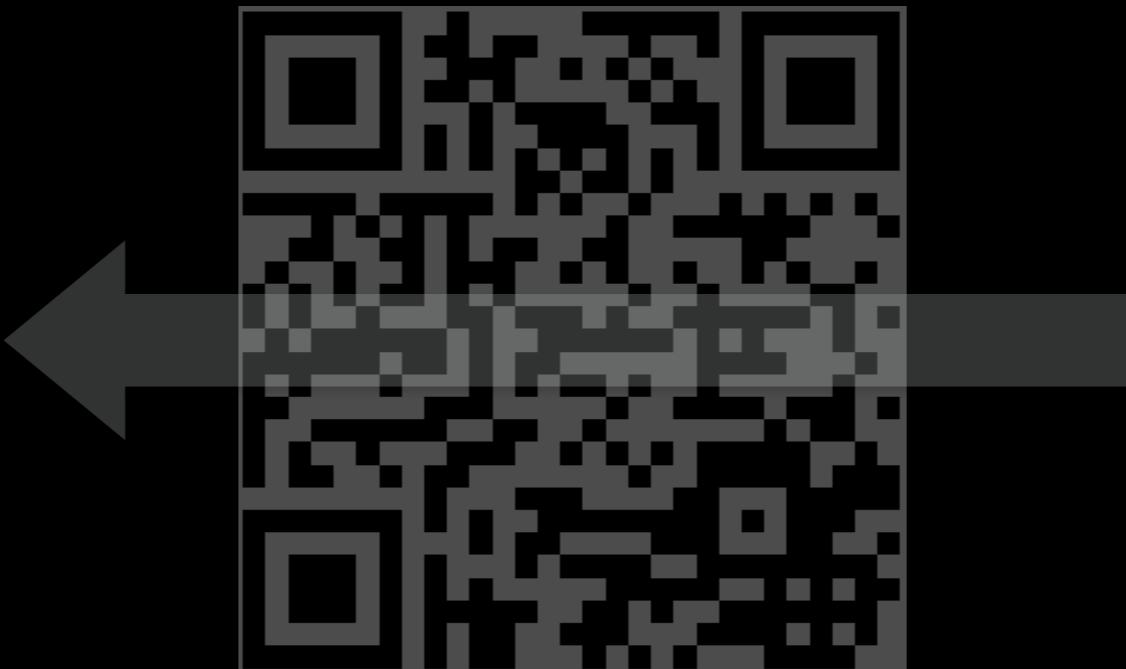
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Tracking Stock Status with QR



Navigate

Scan

Update

Our Algorithm can work With **ANY GROUND ROBOT...**



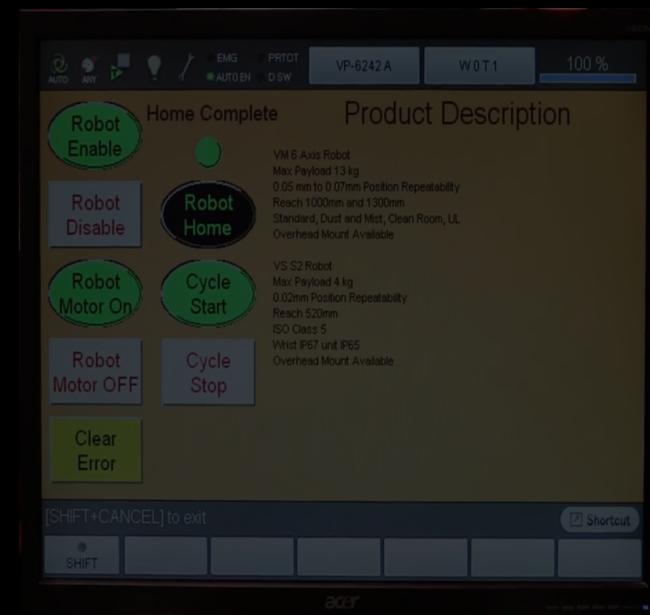
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Tracking Stock Status with QR



Navigate

Scan

Update

... or **ANY QUADROTOR**



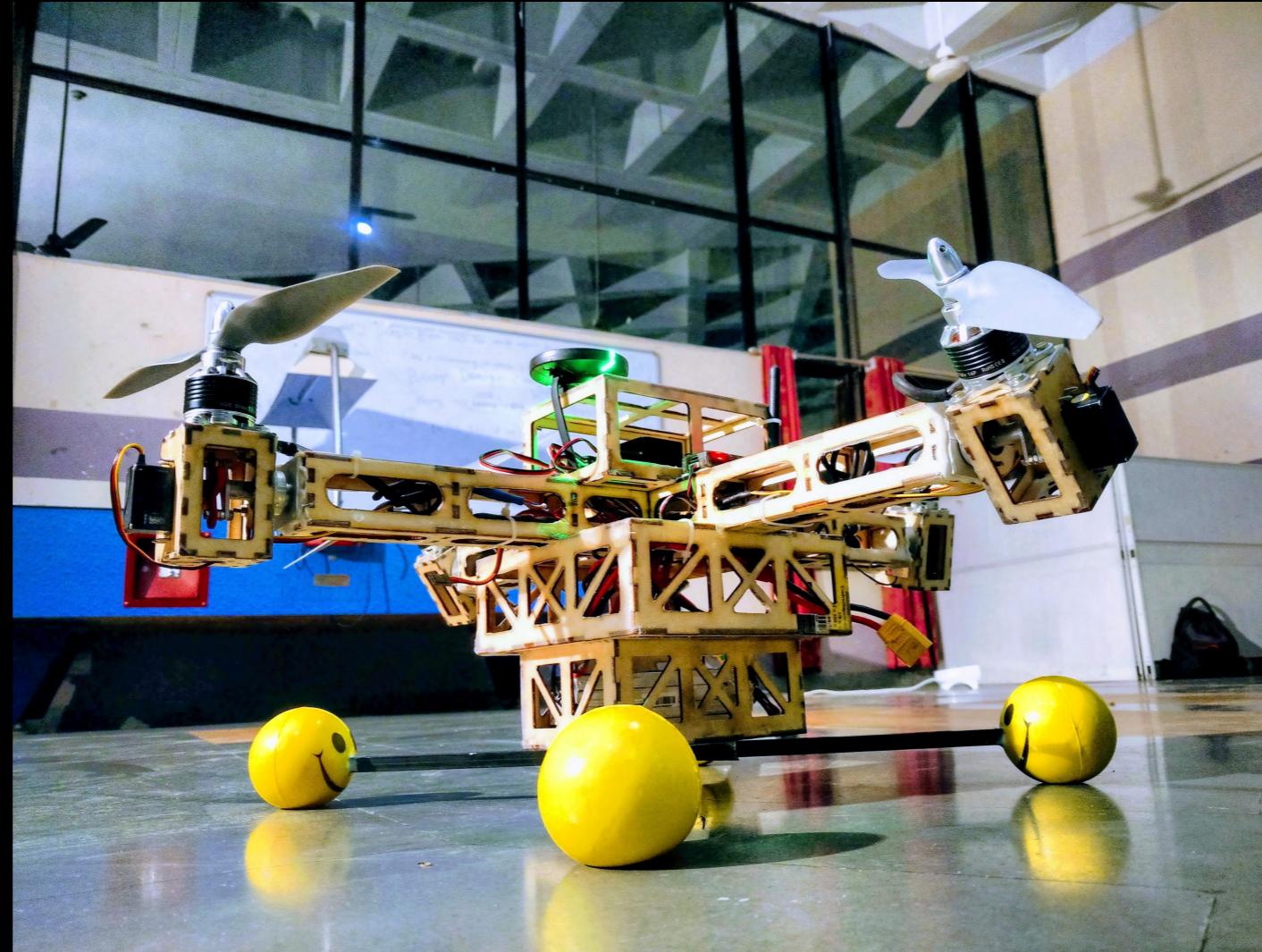
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Image Credits



ASTAiRE



Autonomous Tilt Augmented Aerial Rotary Vehicle (ASTAiRE)



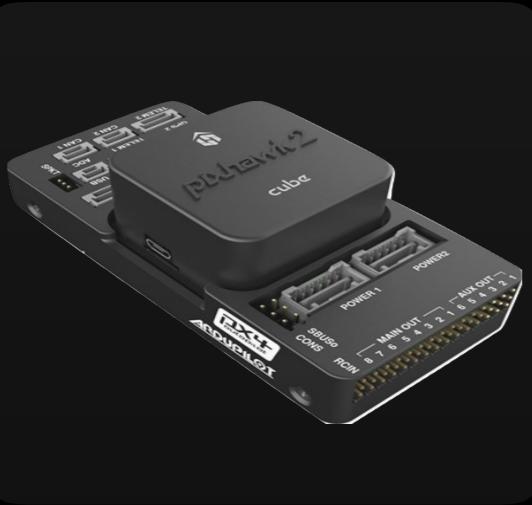
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Jay Patrikar, Mahathi B., Krishnaraj Gaur, Department of Aerospace Engineering, IIT Kanpur

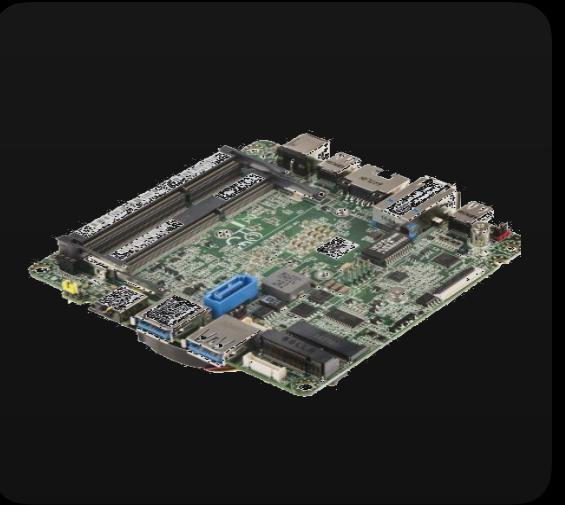
Image Credits



Our Algorithm



PixHawk2



Processor



SONAR



Camera



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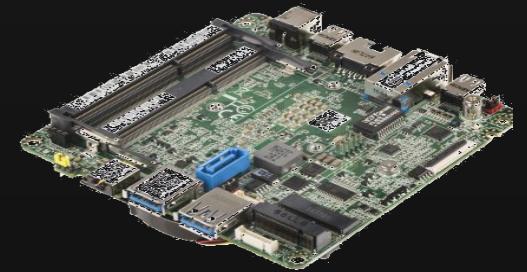


Height & Attitude Estimation



PixHawk2

Processor



SONAR

Camera



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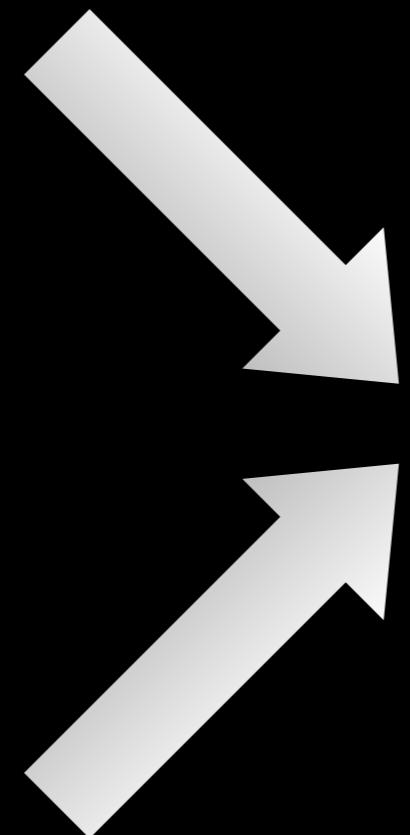
Height & Attitude Estimation



PixHawk2



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**Extended Kalman
Filtering (EKF)**



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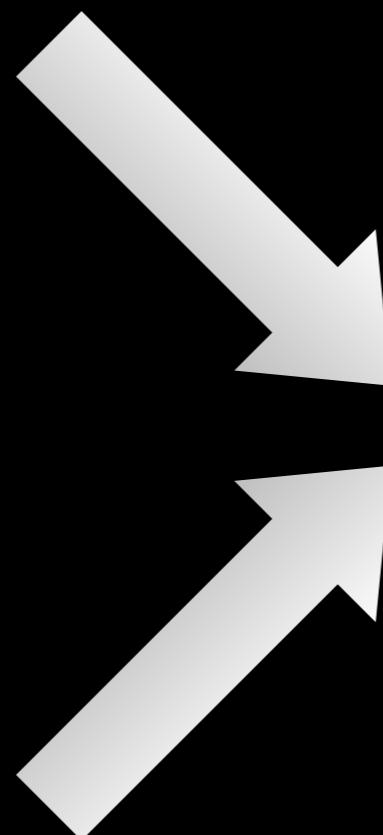
Height & Attitude Estimation



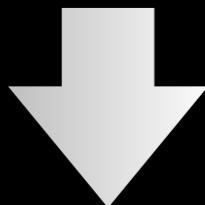
PixHawk2



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Extended Kalman
Filtering (EKF)



$\theta \phi \psi h$

Attitude and Height



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Median Filtering



PixHawk2



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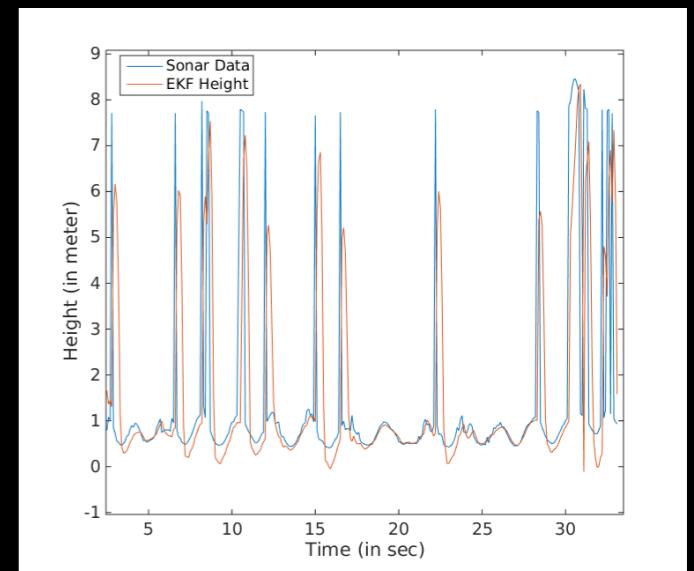
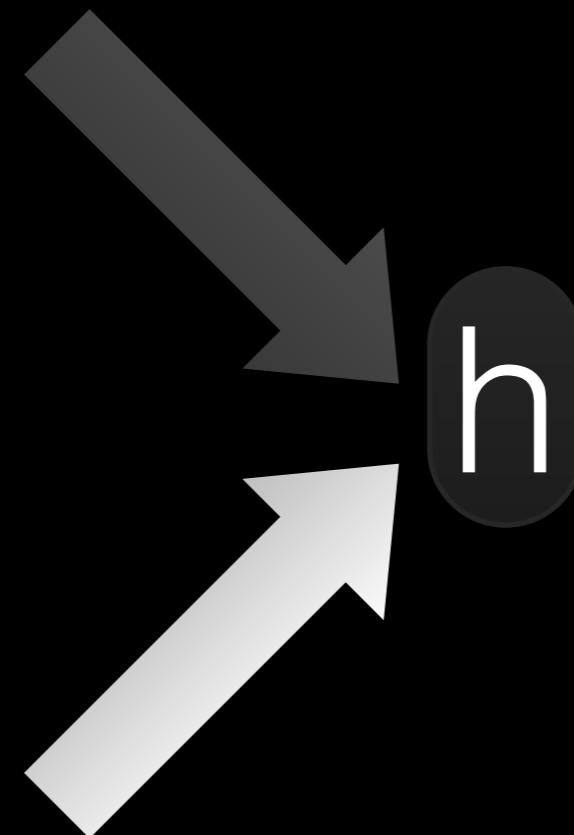
Median Filtering



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The Height Estimation **Degrades Due to High Outliers**



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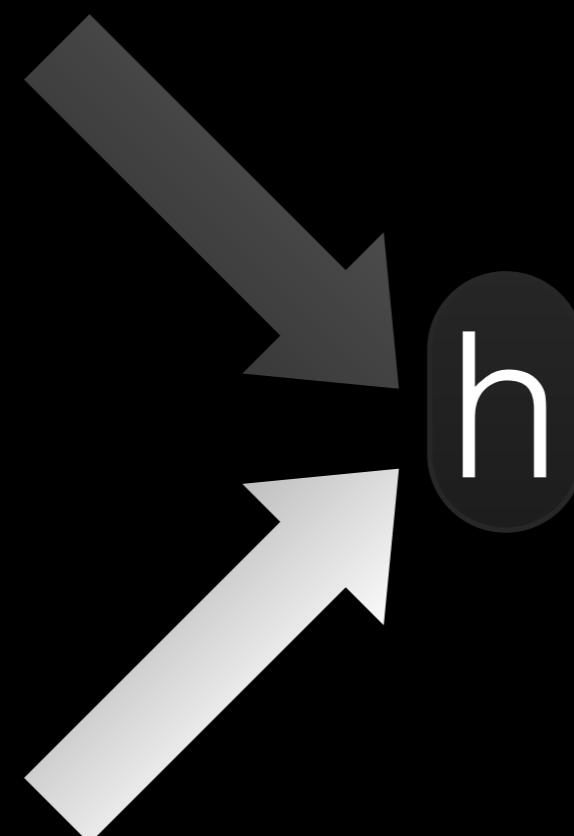
Median Filtering



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Median Filtering



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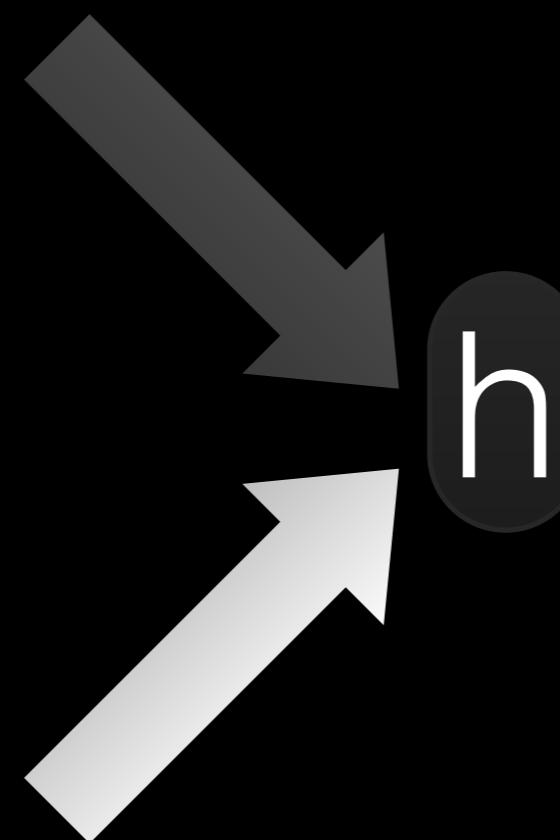
Median Filtering



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Median Filtering



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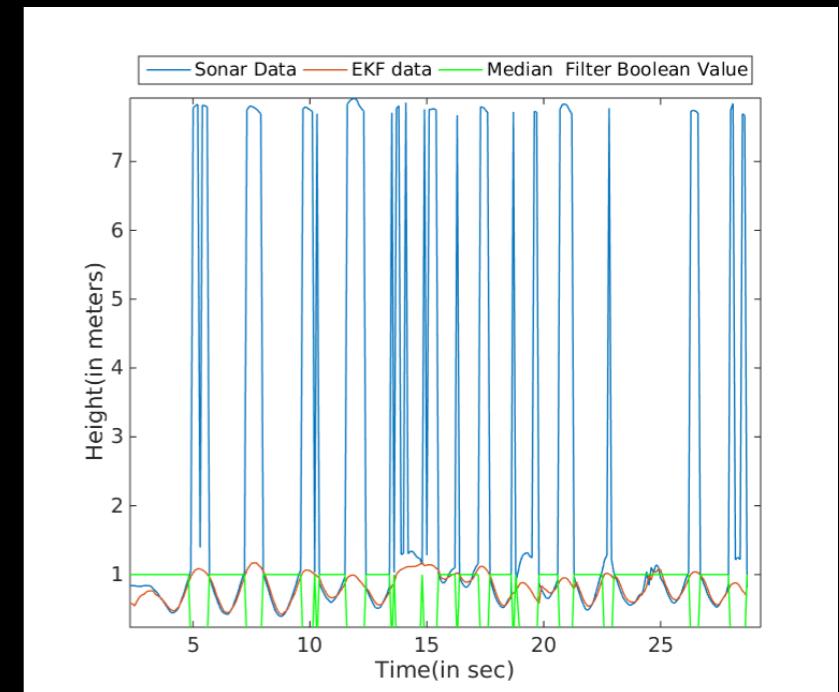
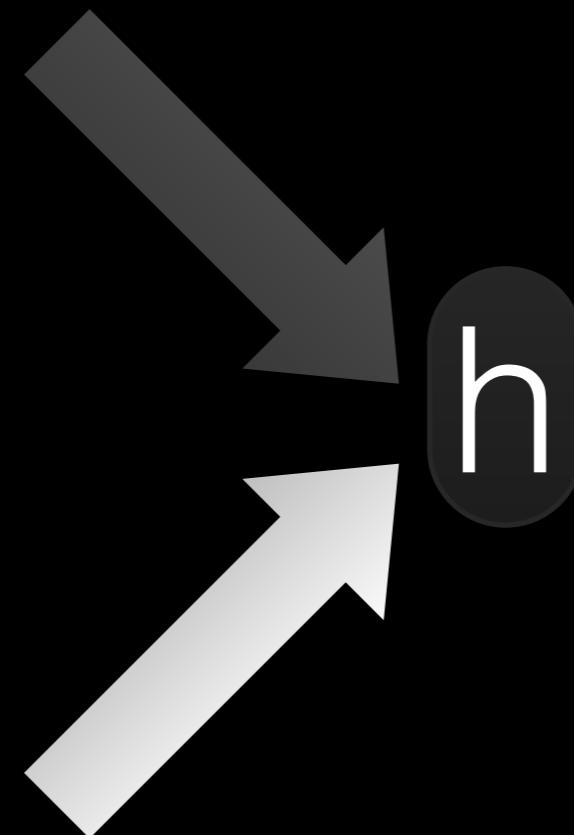
Median Filtering



PixHawk2



SONAR



EKF with Median Filter Output Gives **Noiseless Height Estimates**



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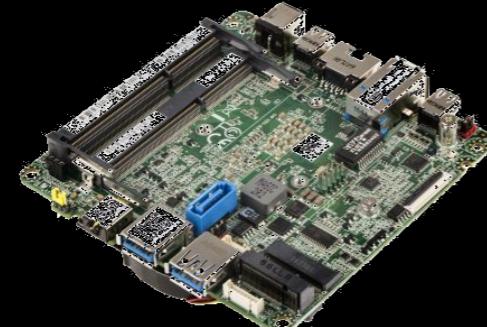
Marker Detection

Camera



Ground Station

Processor



ZBAR with ROS



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Marker Detection



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Camera



Marker Detection



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Marker Detection

Camera

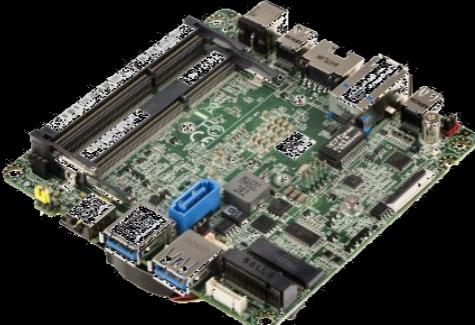


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Marker Detection

Camera



Processor



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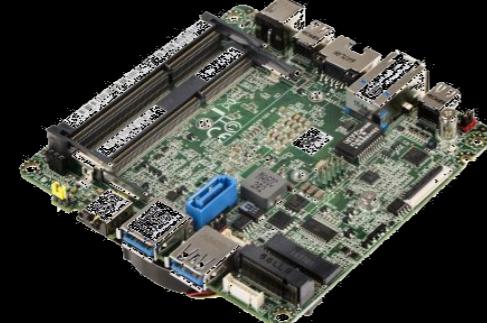


Marker Detection

Camera



Processor



ZBAR with ROS



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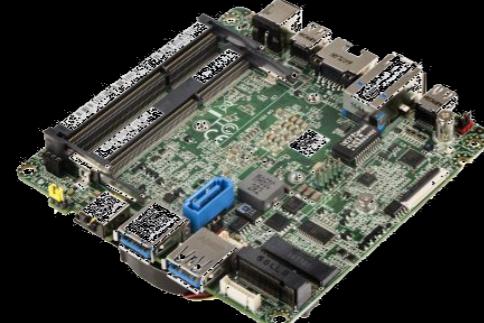


Marker Detection

Camera



Processor



ZBAR with ROS



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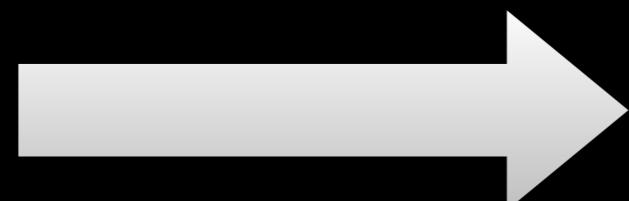
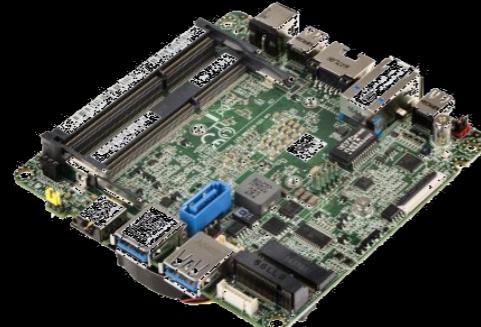
Marker Detection

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Ground Station

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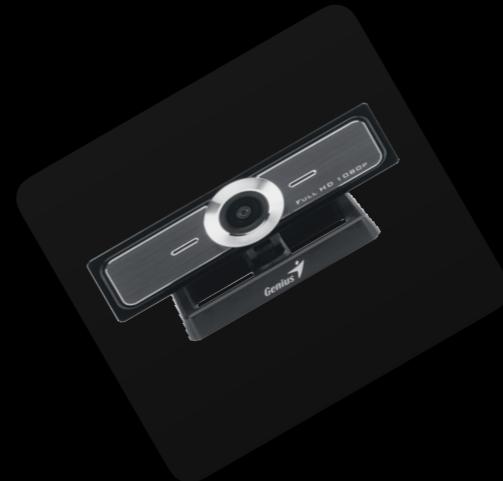
ZBAR with ROS



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Line Detection



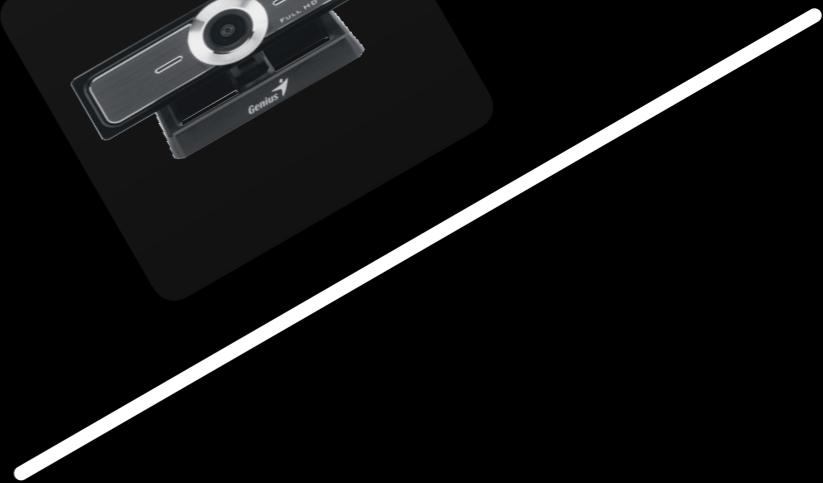
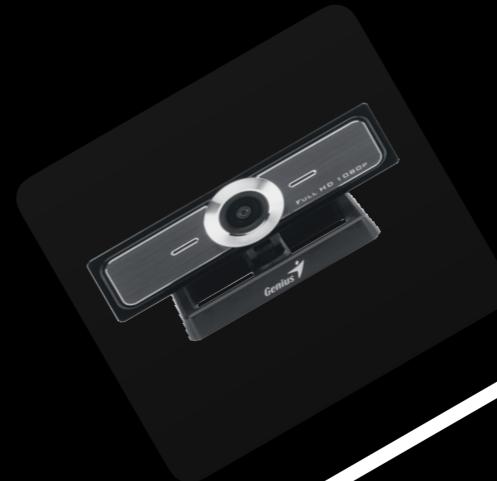
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Line Detection



Image Capture



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Line Detection

Image Capture

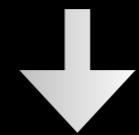
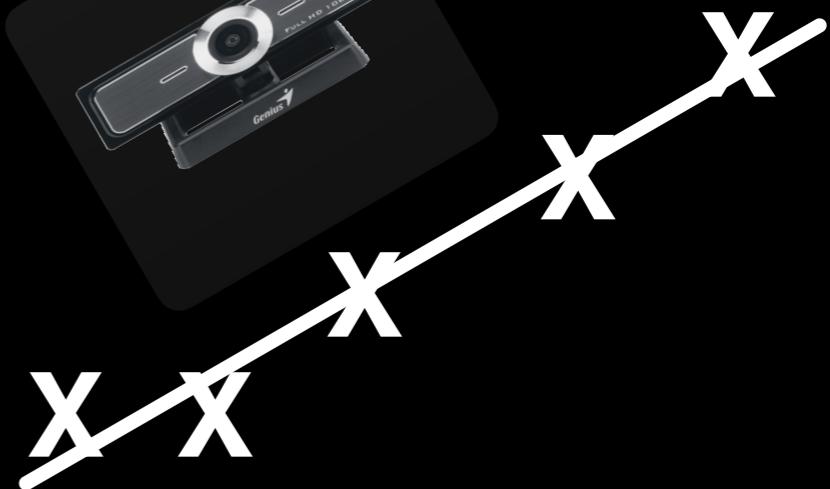
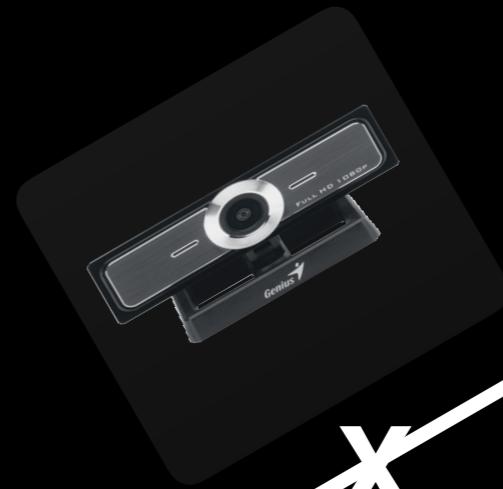


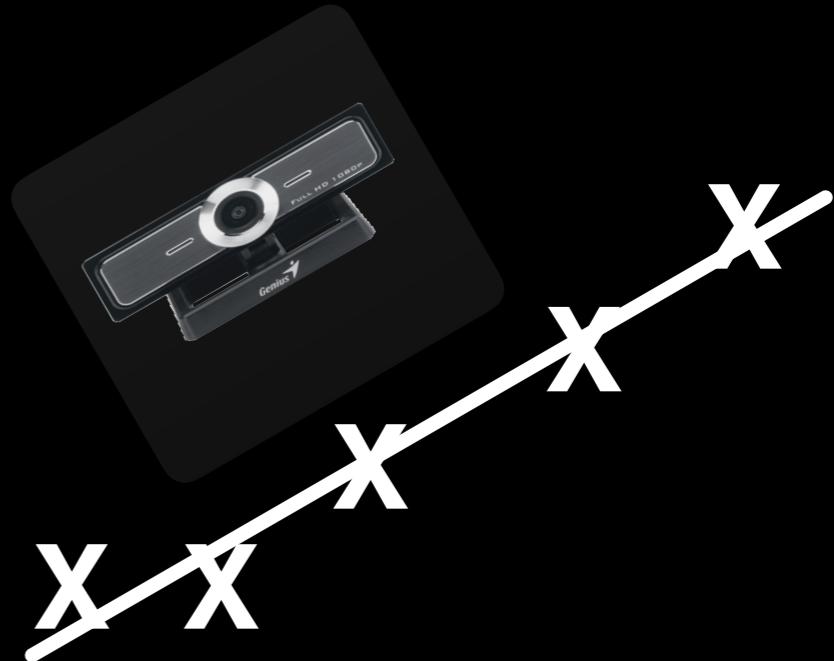
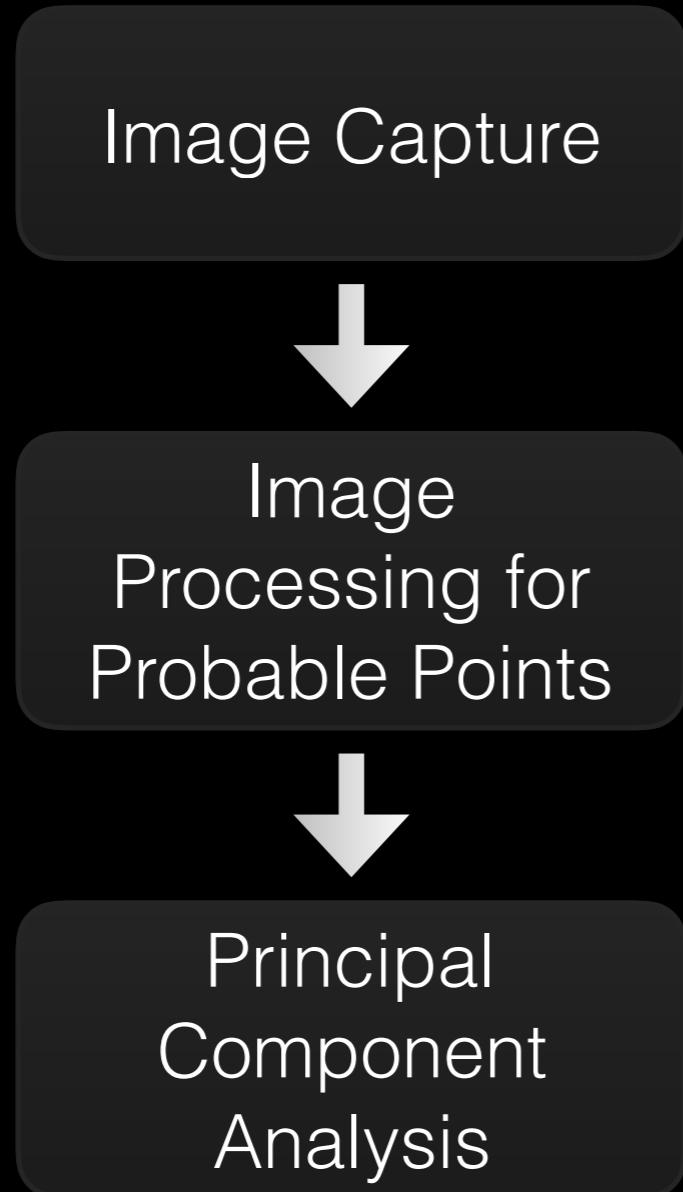
Image
Processing for
Probable Points



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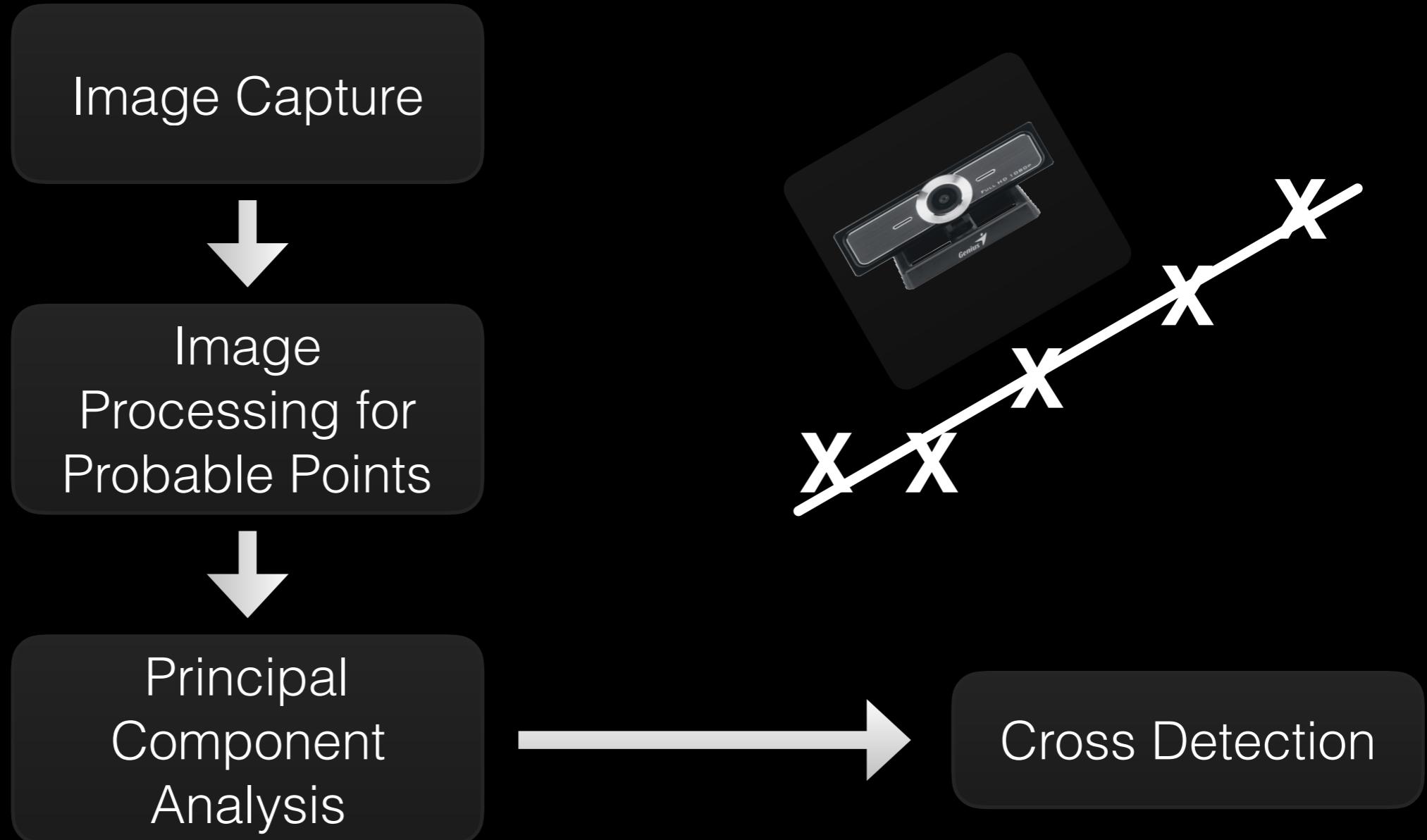
Line Detection



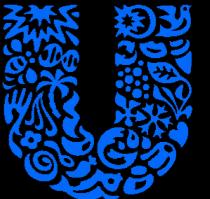
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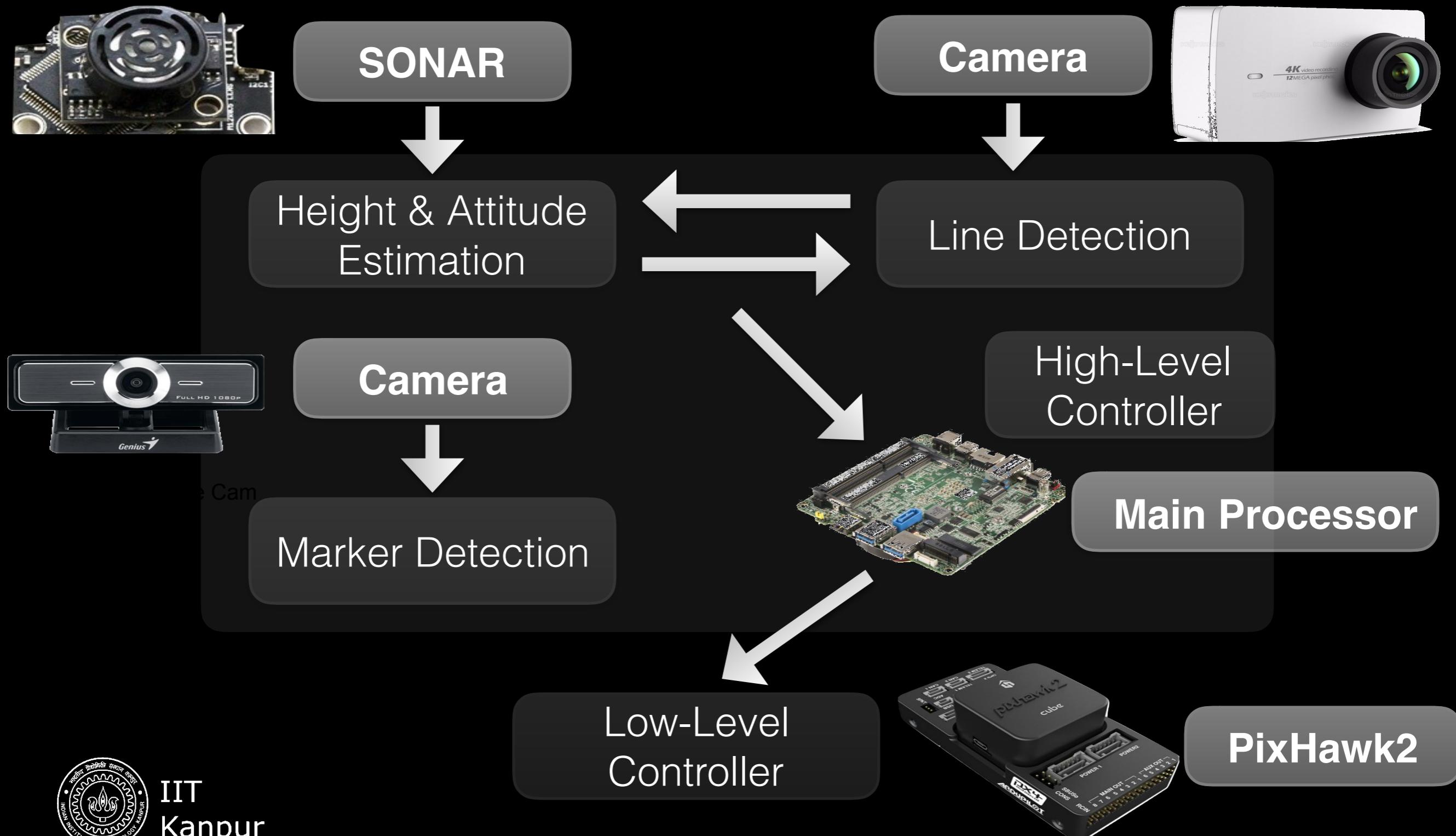
Line Detection



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Algorithm Schematics



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Benefits for HUL



Very Low-Cost Scanning and Inventory Management Algorithms

Fast and Robust Algorithms Capable of Maintaining Precise Records

Flexible Choice of Robotics Systems based on Budget, Needs

Optimal Stock Prediction and Management for HUL's Perishable Goods



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DEMO!!



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Low-Cost Robotics to Replace End-of-Line Manual Work

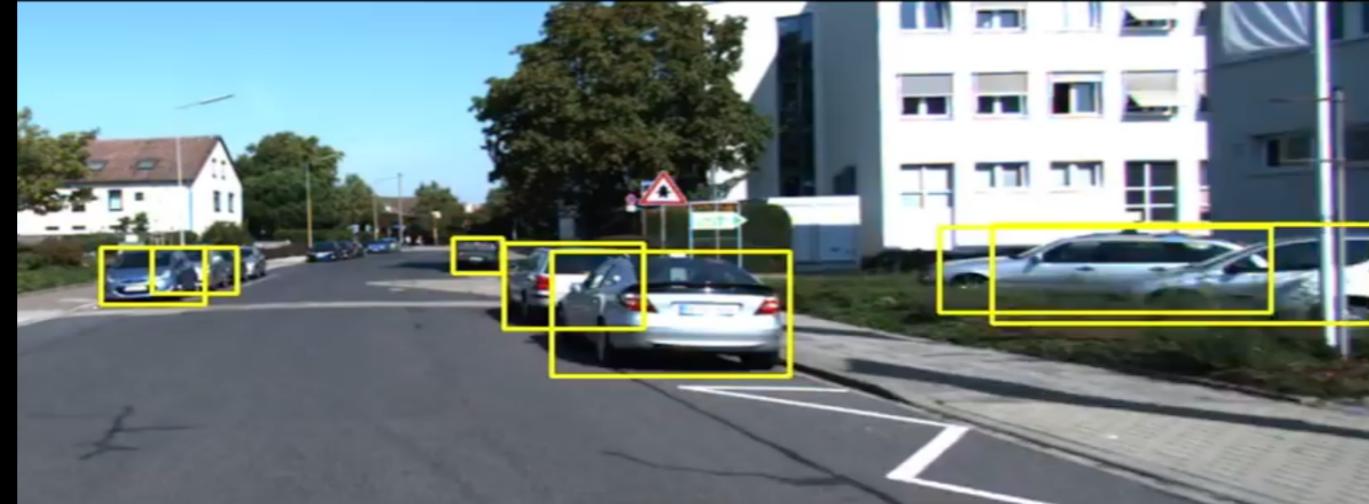
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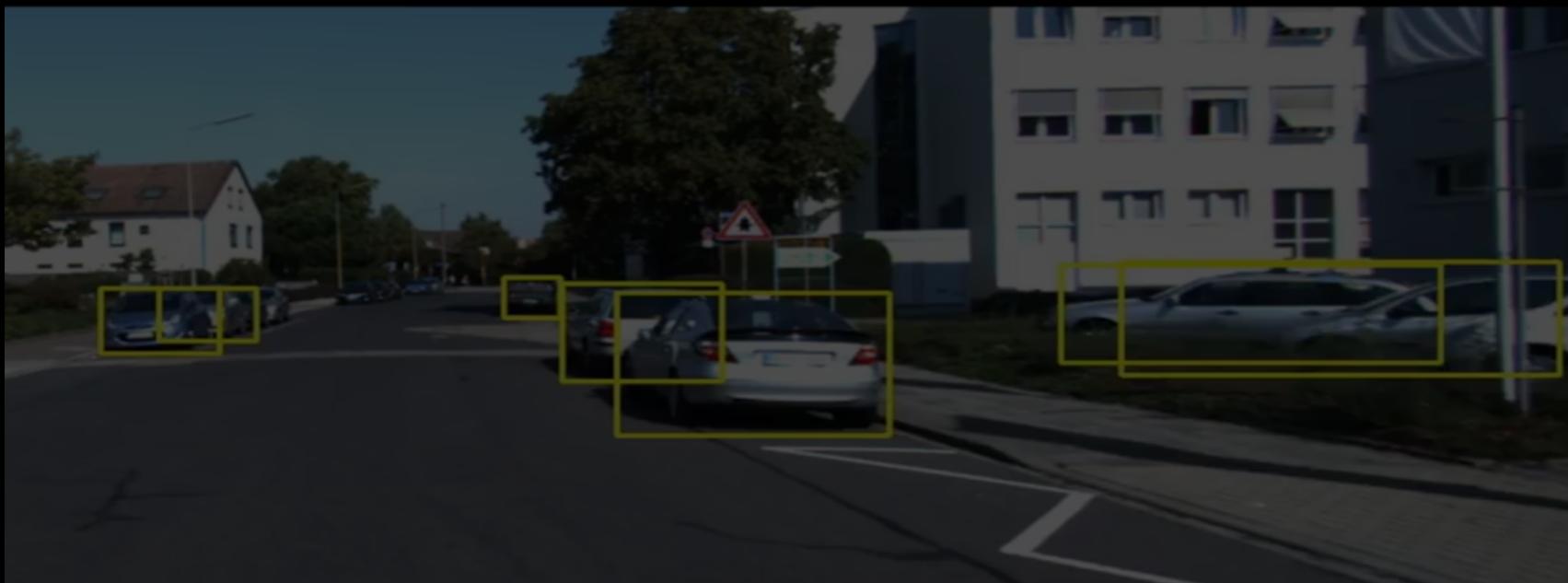
Vehicle/Person Tracking



Detection-Based Tracking



Vehicle/Person Tracking



**Classical
Approaches**

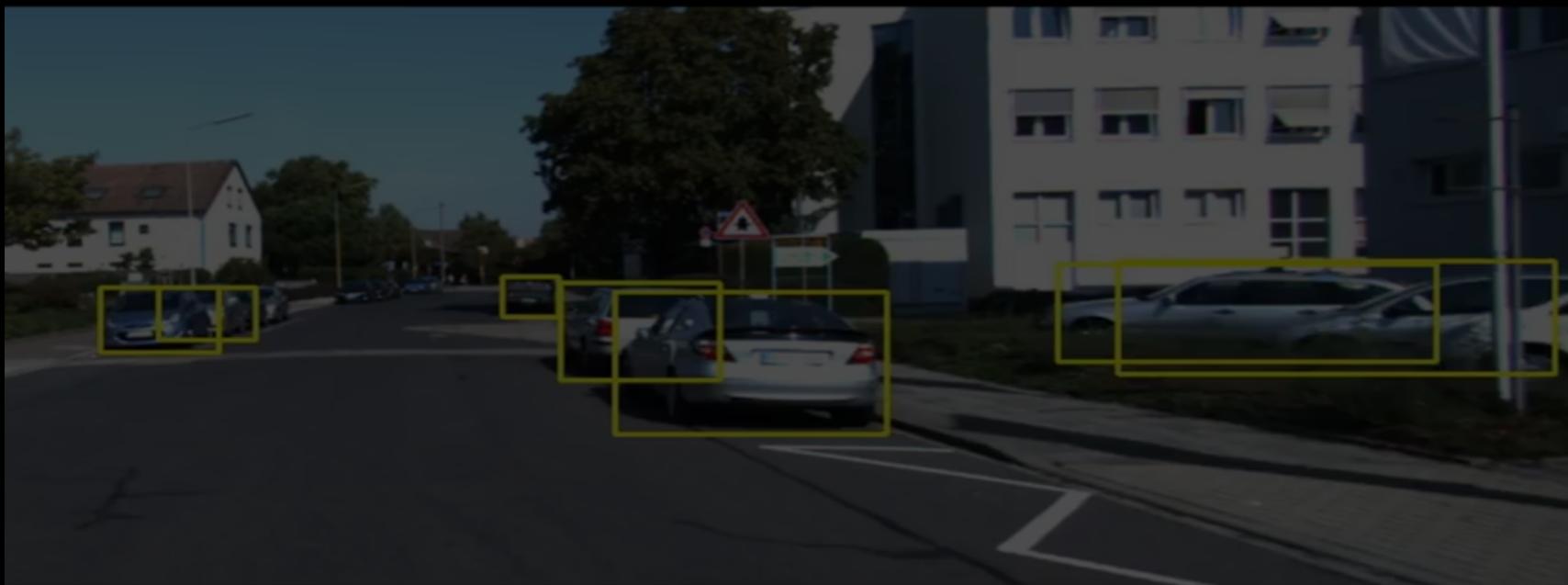
**Deep Vision
Approach**



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Vehicle/Person Tracking



Classical
Approaches

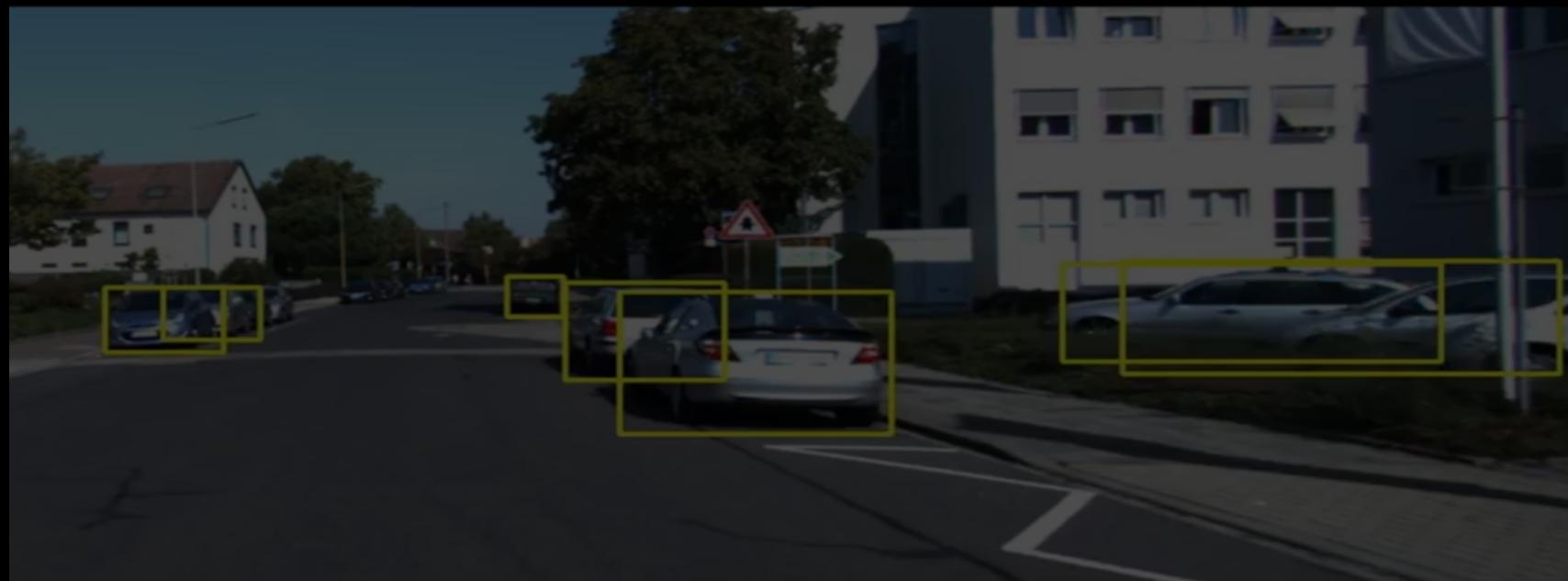
Deep Vision
Approach



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Detection



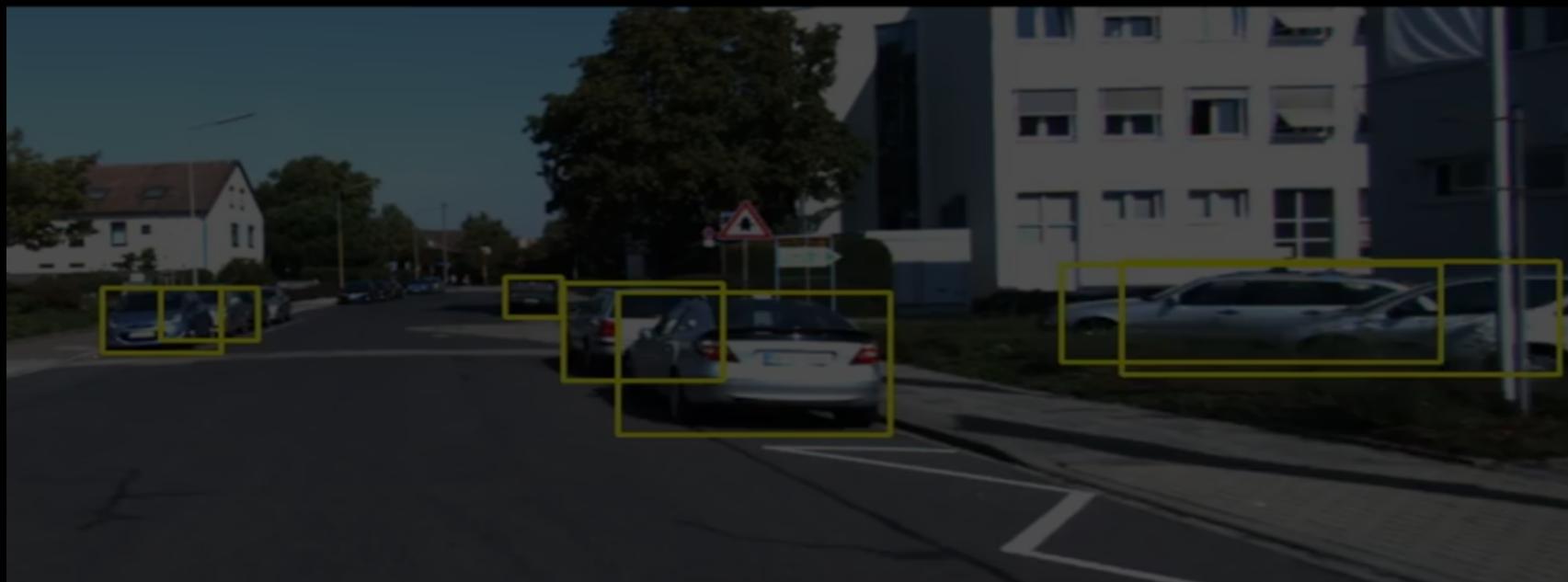
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Image Credits

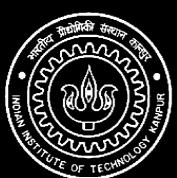
NVIDIA, NVIDIA DRIVENet Demo



Detection



Detection-Based Tracking



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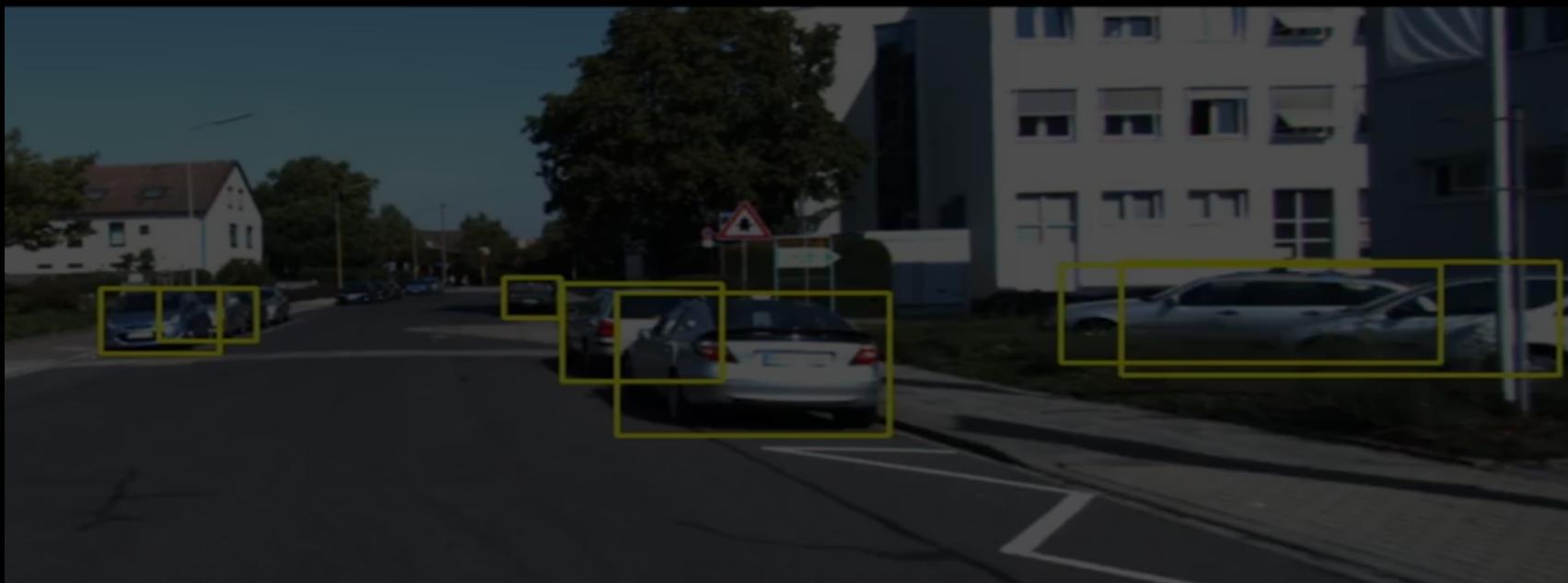
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NVIDIA, NVIDIA DRIVENet Demo



Detection



Deep Learning
with
Convolutional
Neural Nets



Detection-Based Tracking

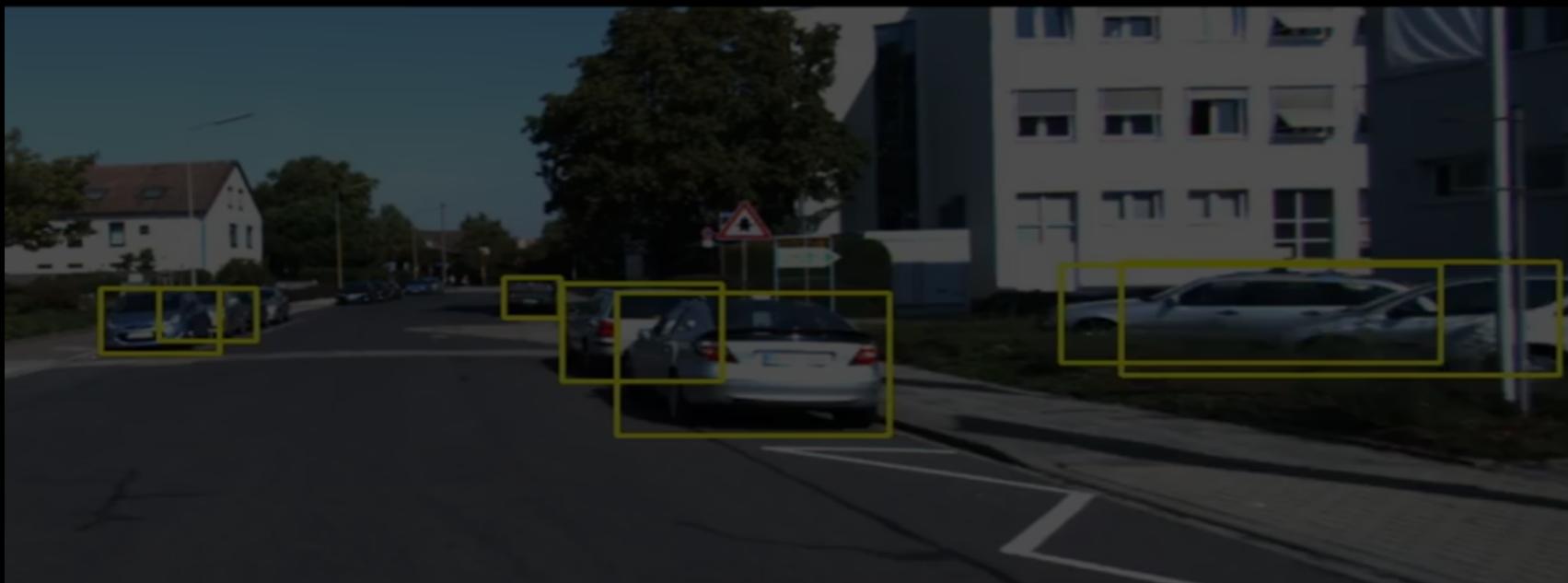


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Image Credits
NVIDIA, NVIDIA DRIVENet Demo

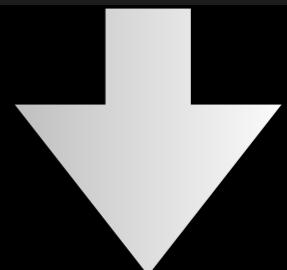


Detection



Detection-Based Tracking

Deep Learning
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Convolutional
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Simultaneous
Multi-Object
Detection

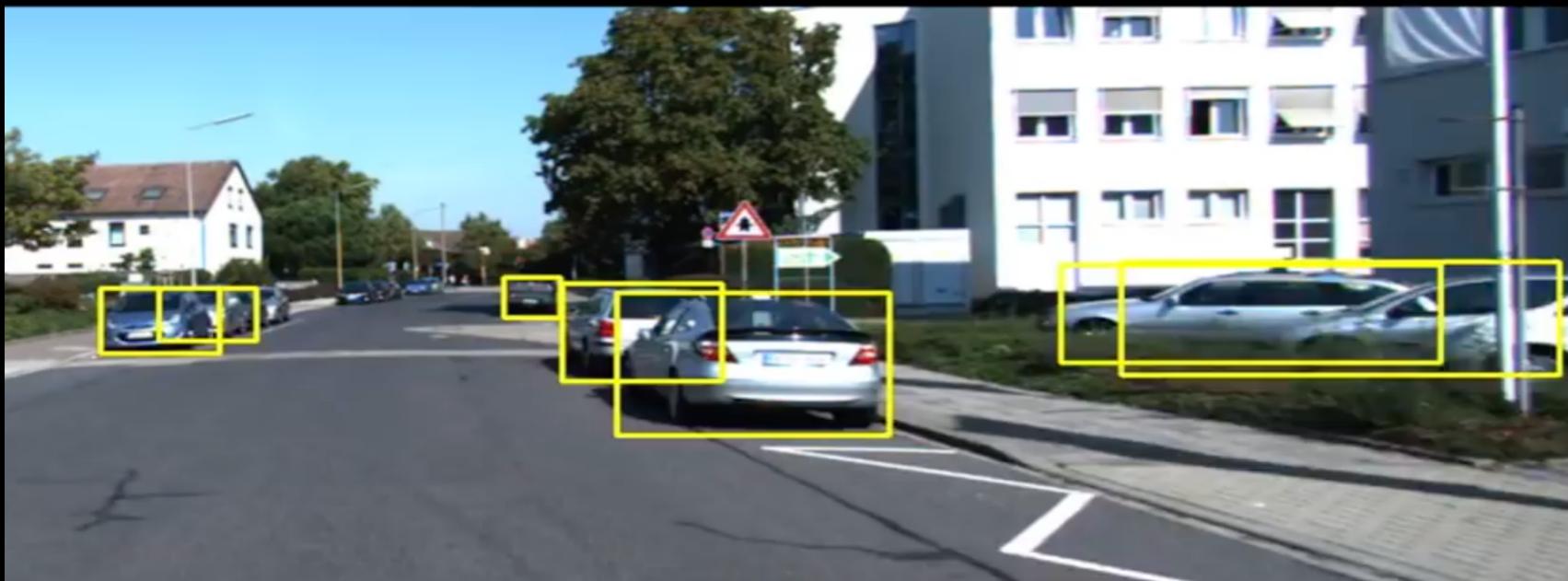


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Image Credits

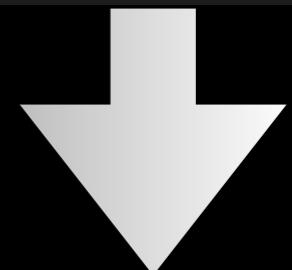
NVIDIA, NVIDIA DRIVENet Demo

Detection



Detection-Based Tracking

Deep Learning
with
**Convolutional
Neural Nets**



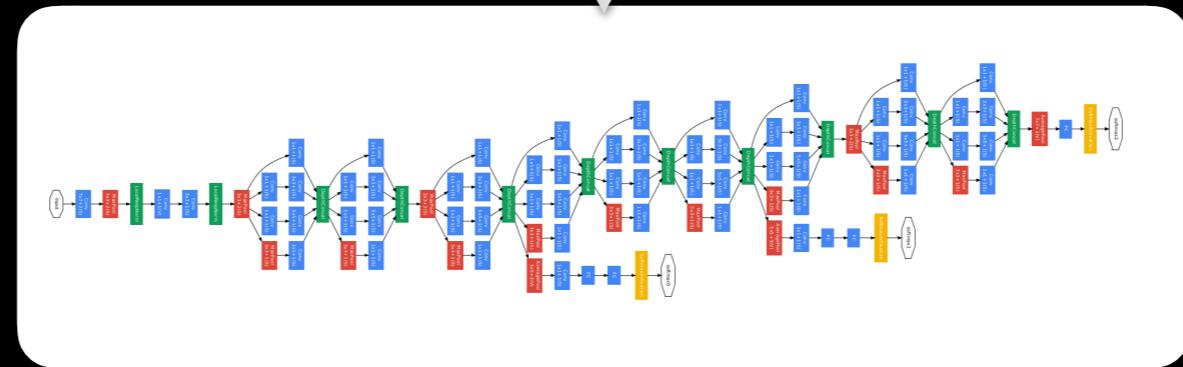
**Simultaneous
Multi-Object
Detection**



Deep CNN-based Detection



Convolutional
Neural Network



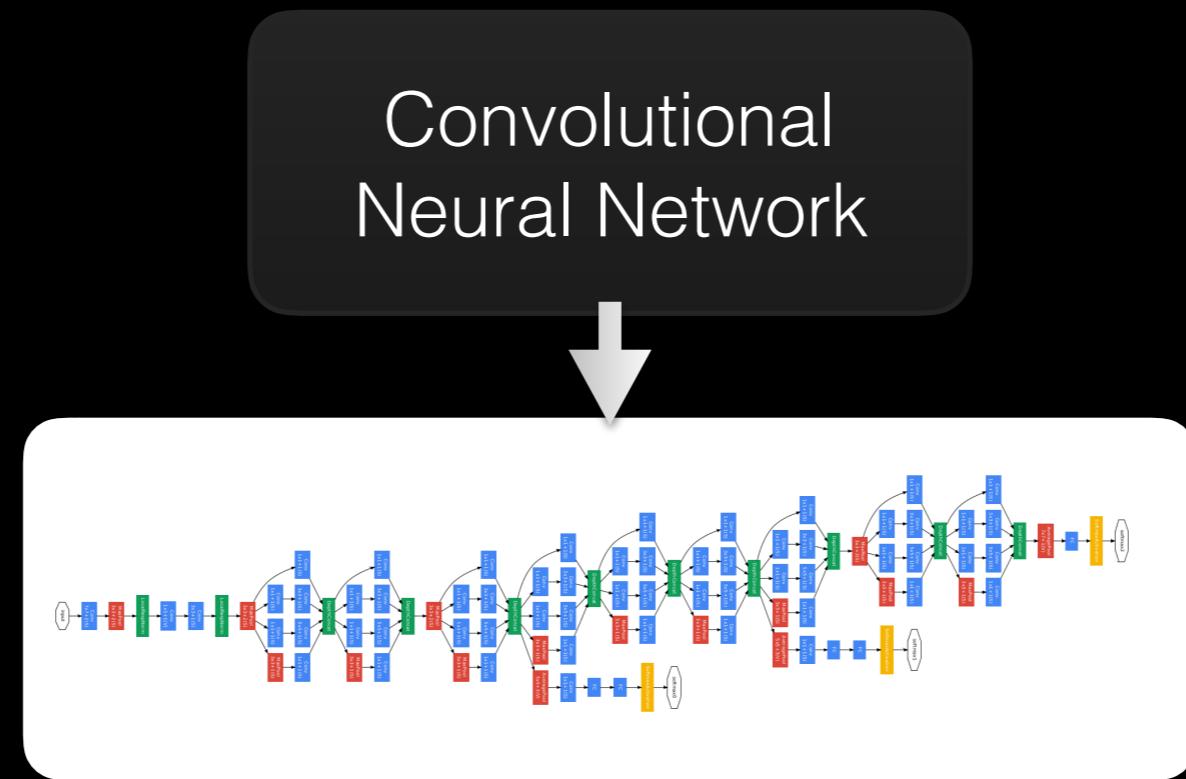
State-of-the-Art Paradigm in Computer Vision (and Regression-AI In General!!)



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Deep CNN-based Detection



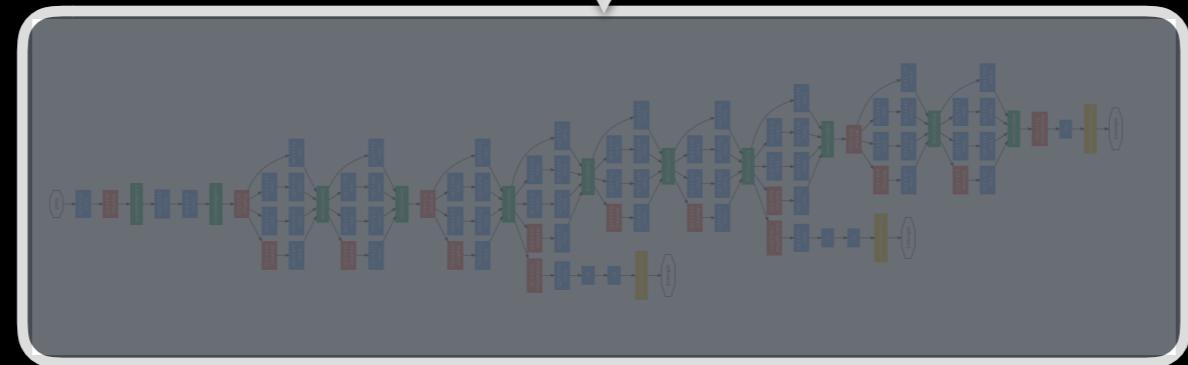
Data-Driven, Highly Generalisable, Robust, Scalable and Real Time Approach



Deep CNN-based Detection



Convolutional
Neural Network



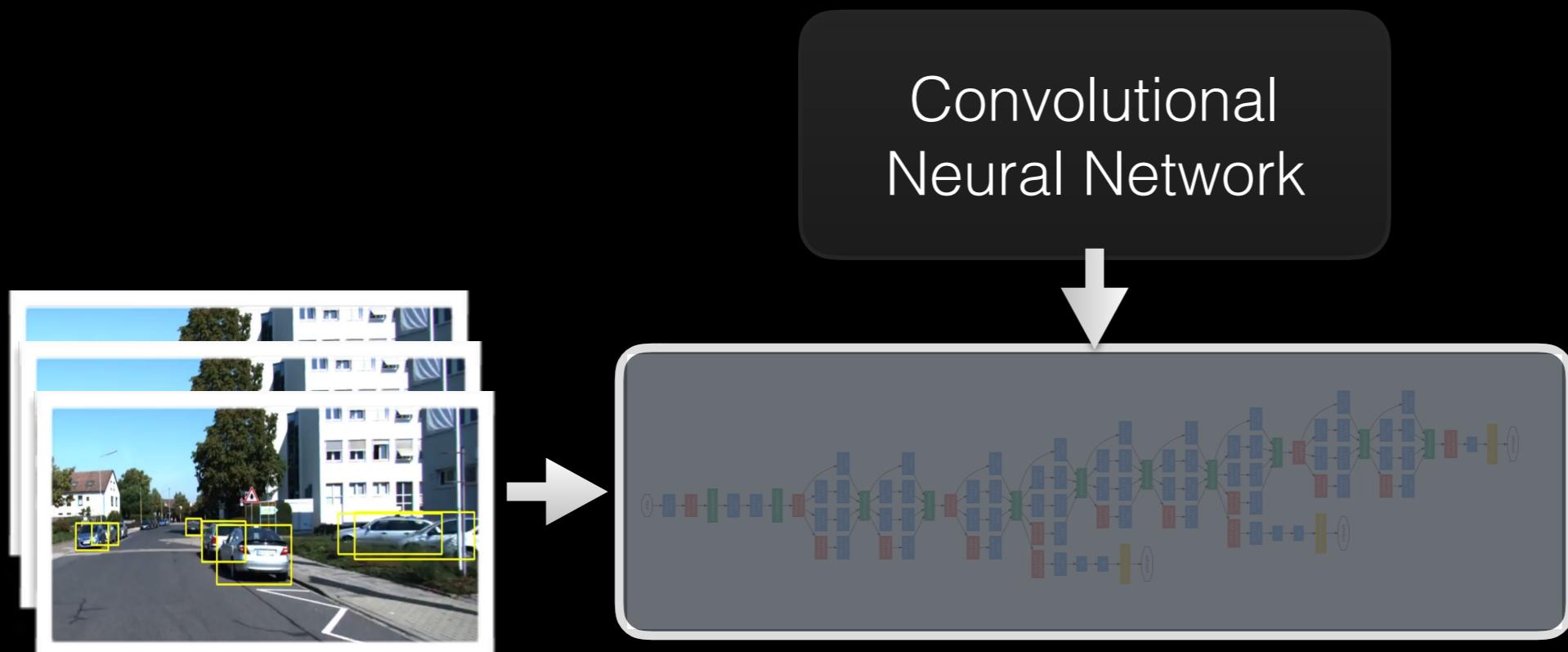
Initially the CNN is Random/Pre-trained Initialised and is NOT Task Specialised



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Deep CNN-based Detection



During Training Phase, Visual Input with Detection Regression is Supplied



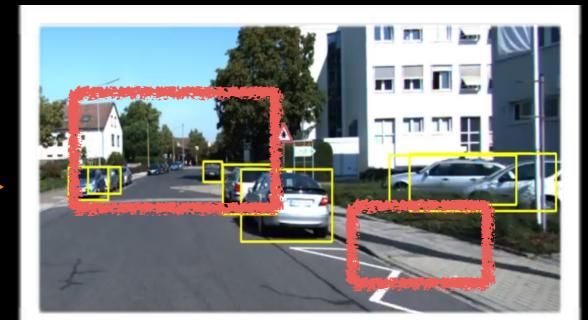
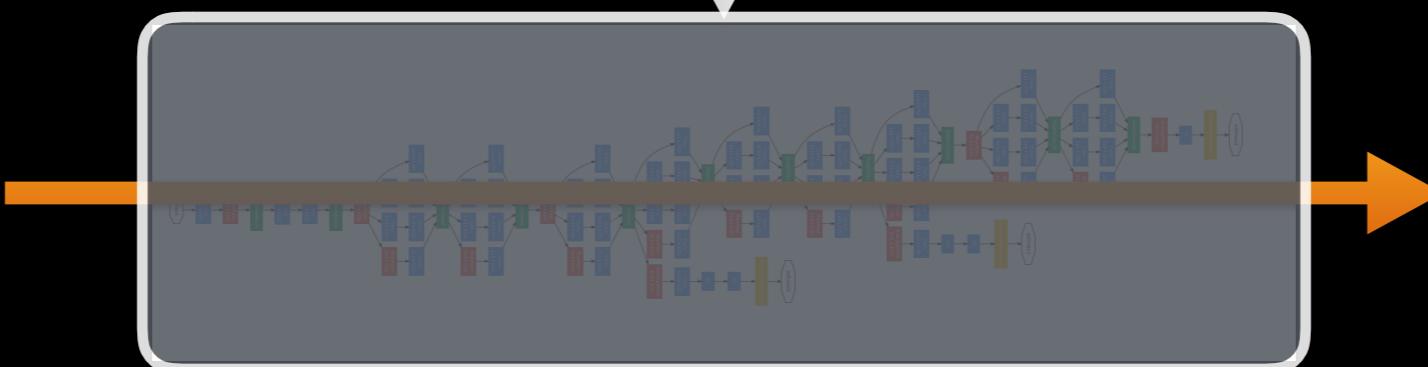
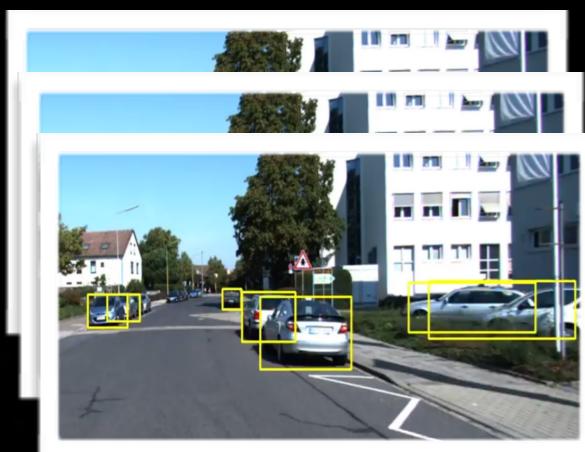
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Deep CNN-based Detection



Convolutional
Neural Network



The CNN Predicts the **Detection Regressors**



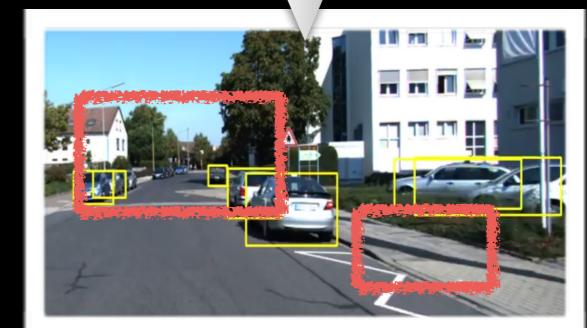
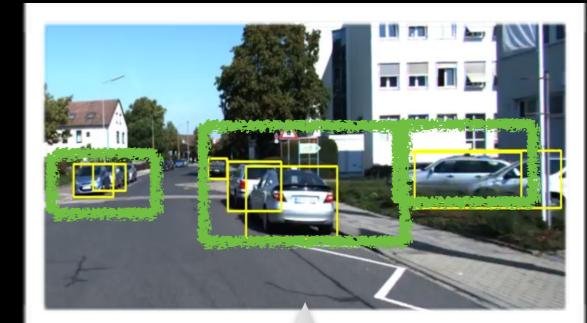
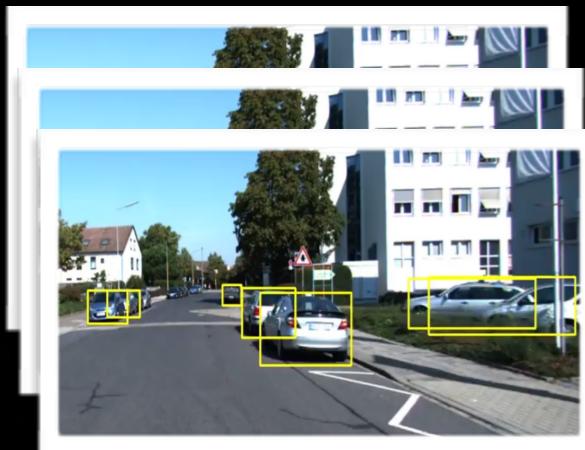
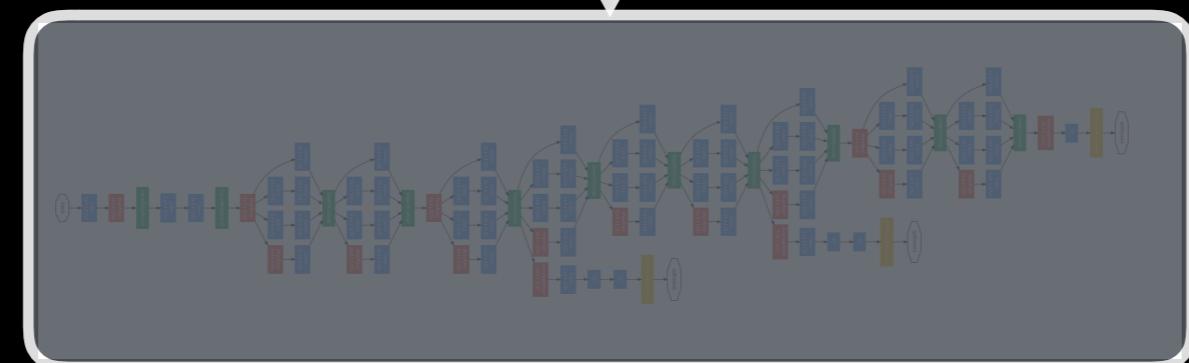
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Deep CNN-based Detection



Convolutional
Neural Network

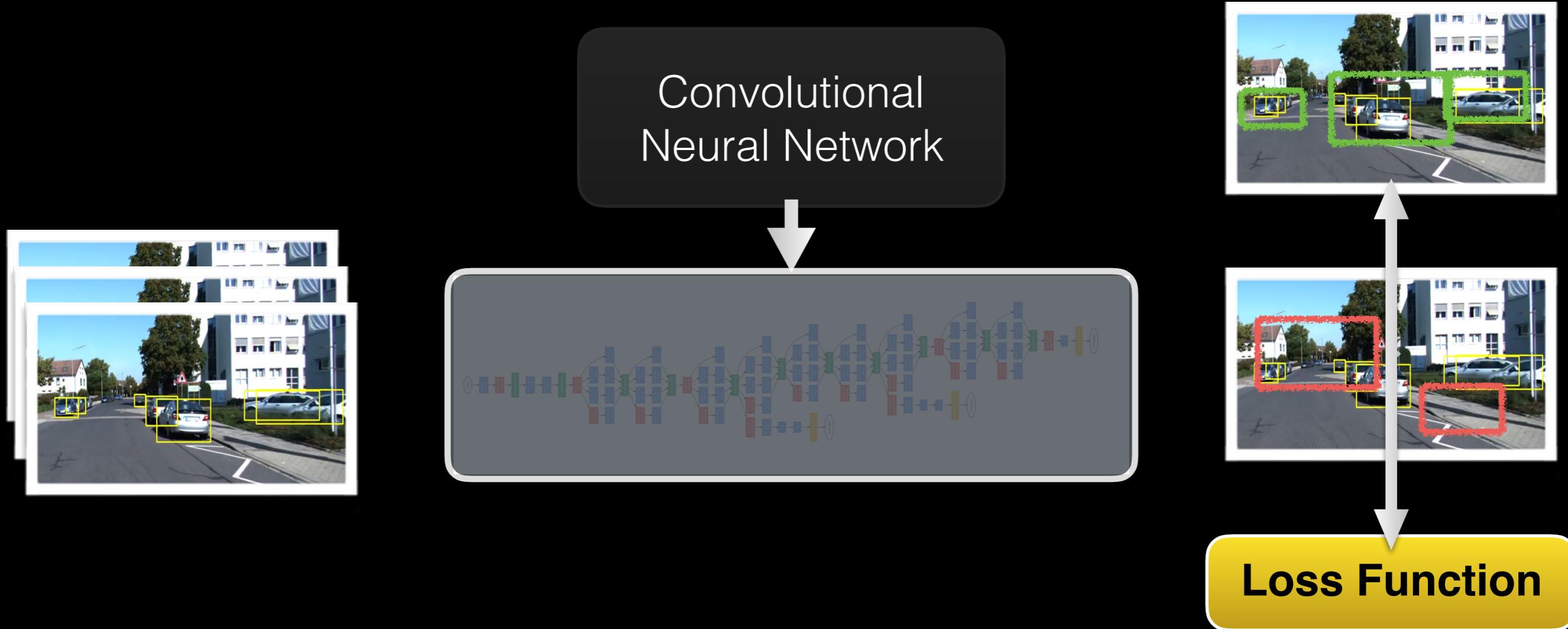


Prediction is Compared with the **Ground Truth Detection Regressors**



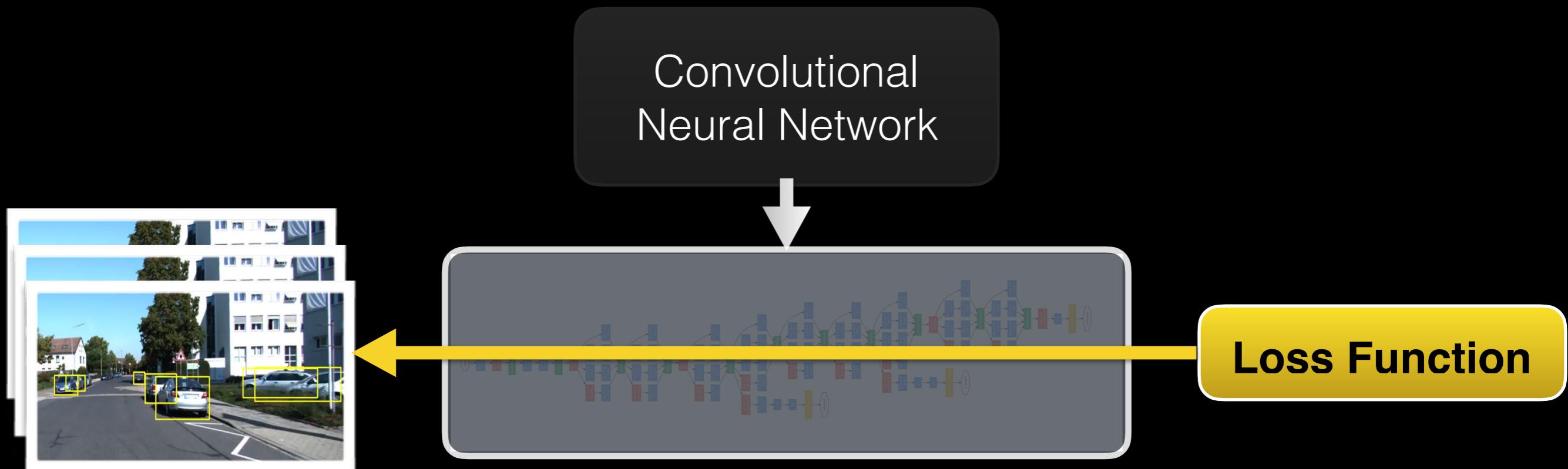
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Deep CNN-based Detection



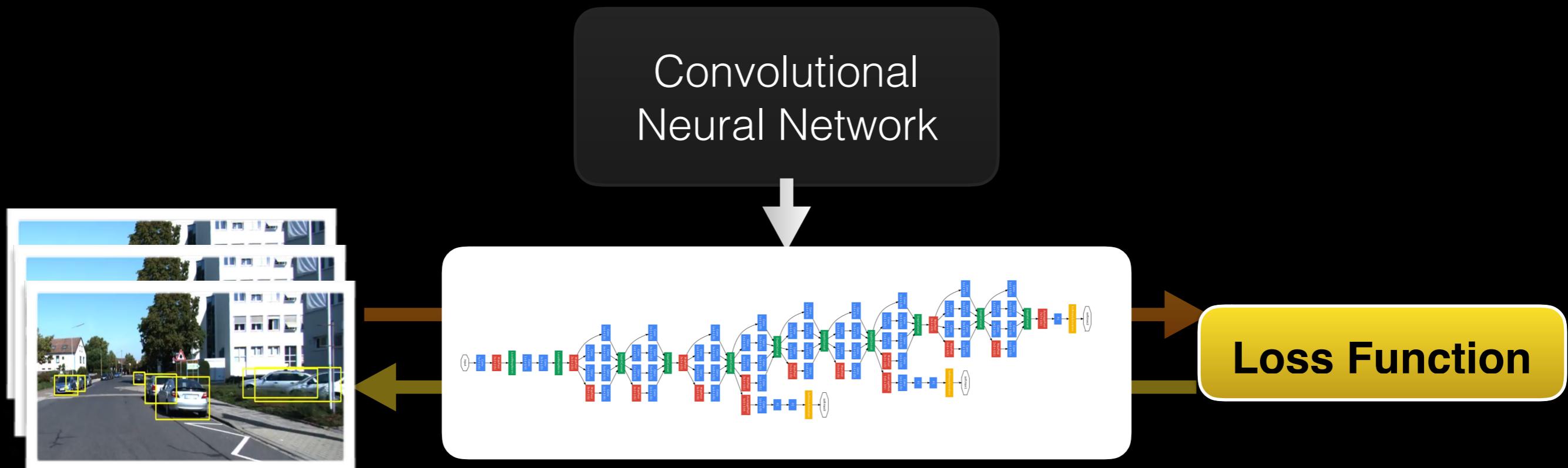
The Disparity is Measured in Terms of Appropriate **Loss Function**

Deep CNN-based Detection



The Loss is **Backpropagated** to Train the Network to Reduce the Error

Deep CNN-based Detection



With Sufficient Training Data, the CNN is Trained and Fine-Tuned!!



Implementation



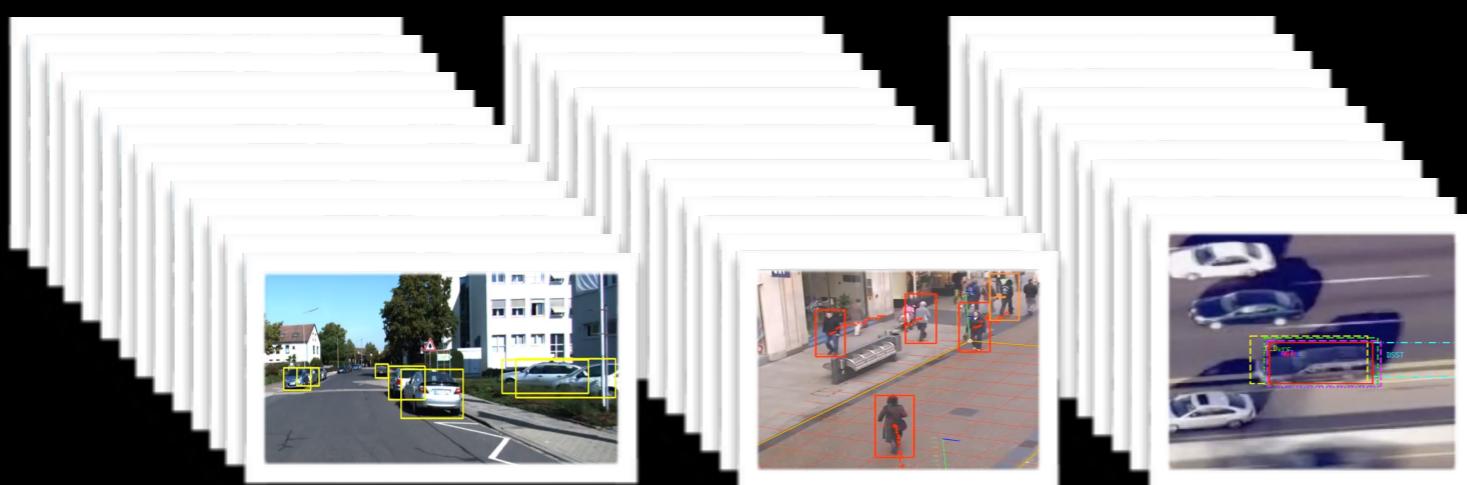
Training Deep Networks Requires Huge Amounts of Data



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Implementation



We Propose to Use Visual Inputs from HUL's Surveillance Cameras



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Image Credit
OSA Integrated Solutions



Implementation



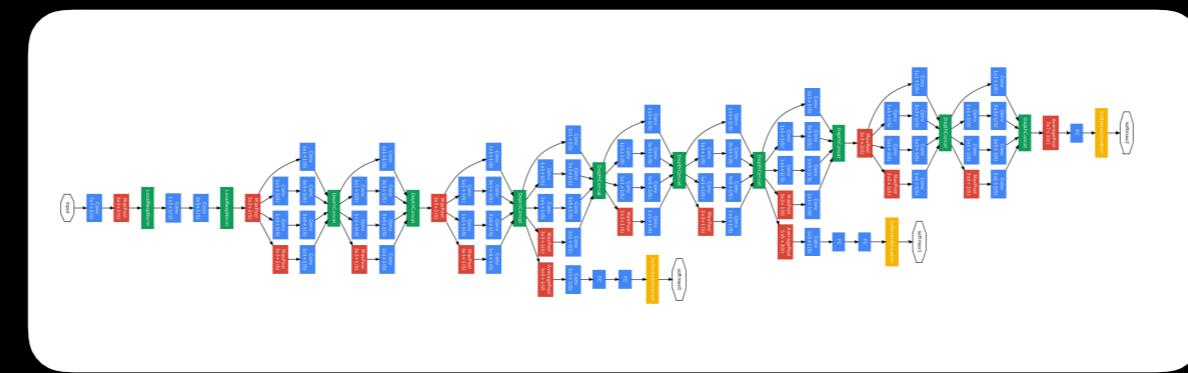
Huge Amounts of Data NOT AVAILABLE



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Implementation



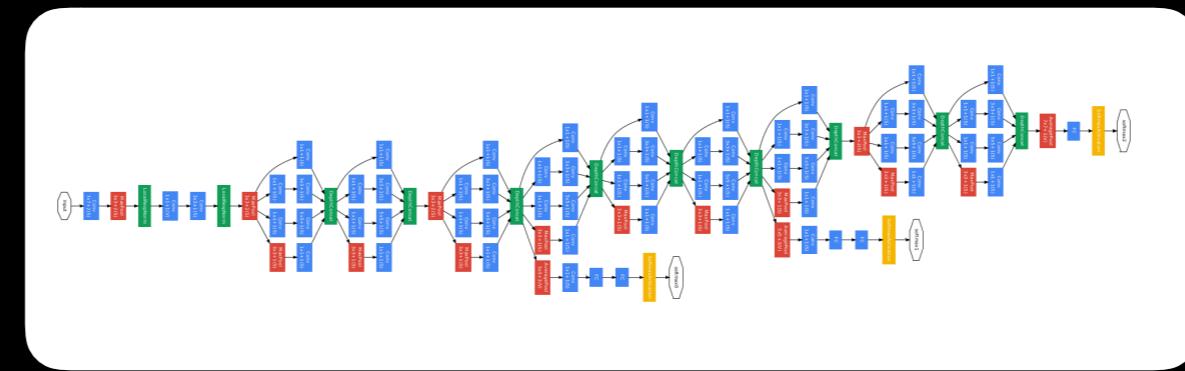
We use Pre-Trained Models Made Available by TensorFlow!!



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Implementation



Trained on MS-COCO (Huge dataset, $\sim 1e5$ Iterations), Accurate, Robust and ...



Implementation

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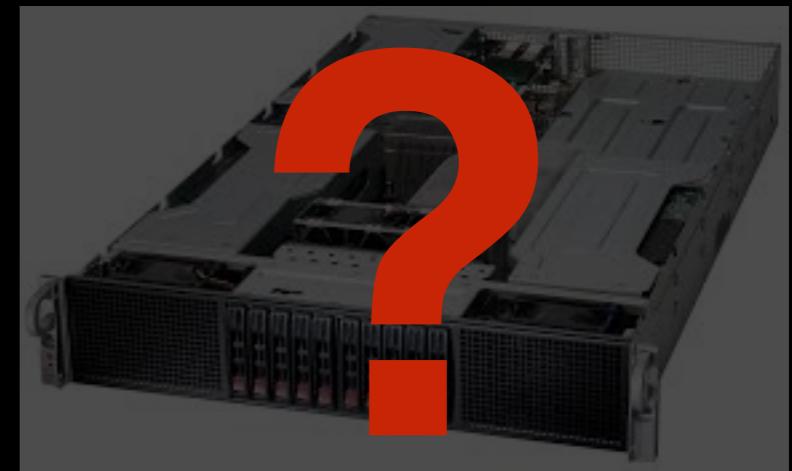
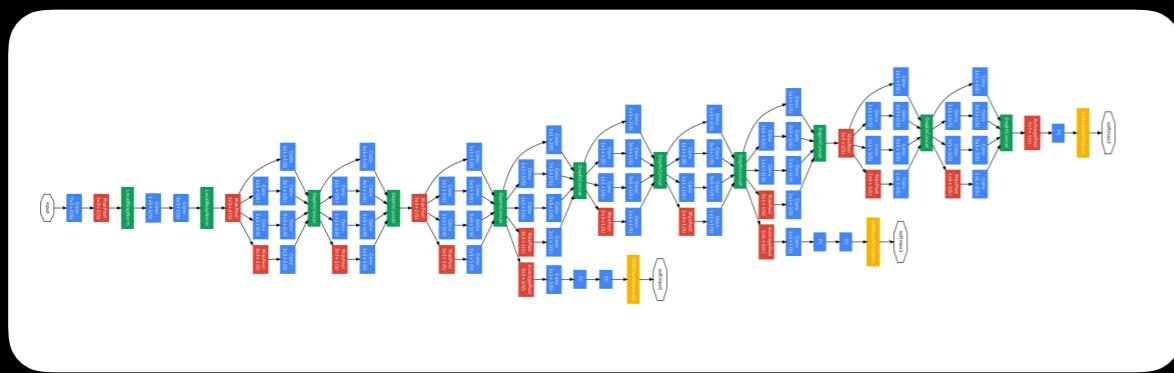
... License for Commercial Development!!



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Implementation



Training Deep Neural Networks is Computation Intensive

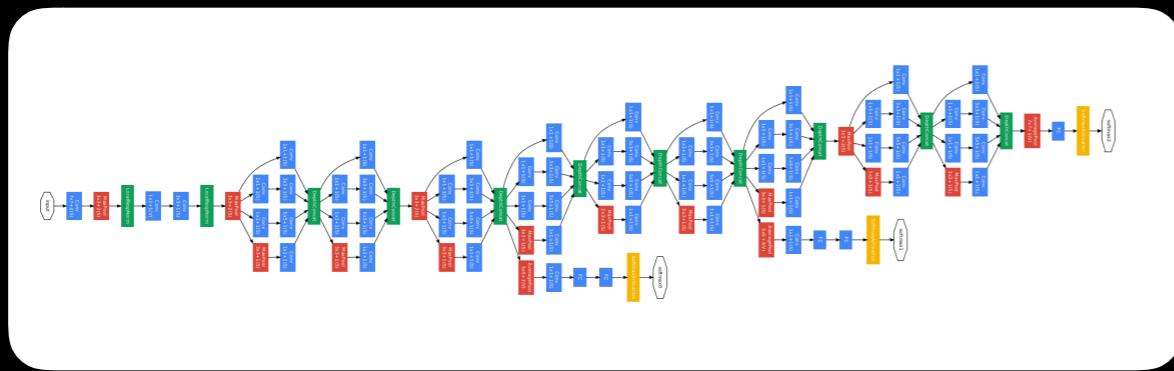


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Implementation



NVIDIA GPU Clusters Increase Computation Power by ~16%



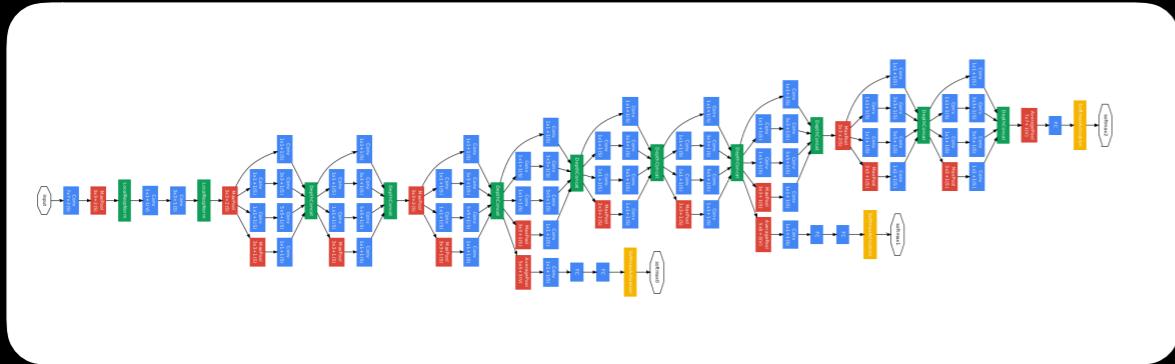
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Implementation



```
tf.train.ClusterSpec({
    "worker": [
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        "worker1.example.com:2222",
        "worker2.example.com:2222",
        "worker3.example.com:2222",
        "worker4.example.com:2222",
        "worker5.example.com:2222",
        ...
    ],
    "ps": [
        "ps0.example.com:2222",
        "ps1.example.com:2222",
        "ps2.example.com:2222",
        "ps3.example.com:2222",
        ...
    ]
})
```

Coding Deep Learning Algorithms Requires Multi-System, Efficient Platforms



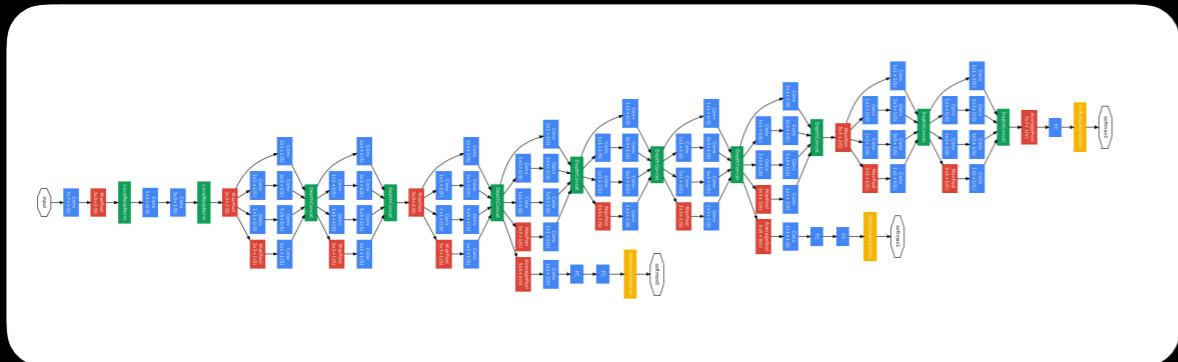
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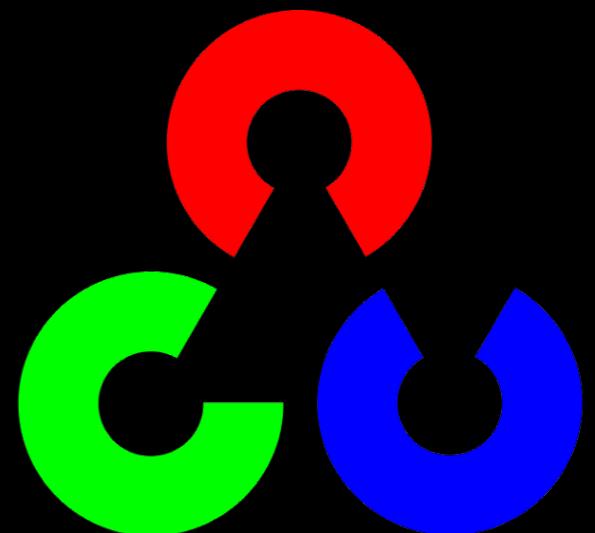
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Implementation



Caffe
+ Caffe2



TensorFlow, Caffe/Caffe2, openCV



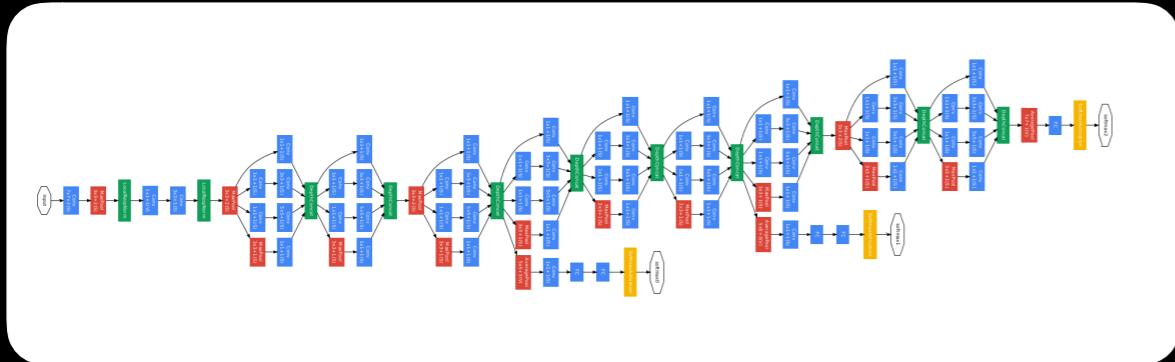
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Implementation



 TensorFlow
 Caffe
+  Caffe2

The central text "Caffe" is in a large, bold, dark red font. Below it, the text "TensorFlow" is in a brown font, accompanied by its characteristic orange "T" logo. To the right of "Caffe2", there are three large, overlapping letters "C" in red, green, and blue, with a black outline.

We Have Extensively Used and Have Expertise In These!! And...



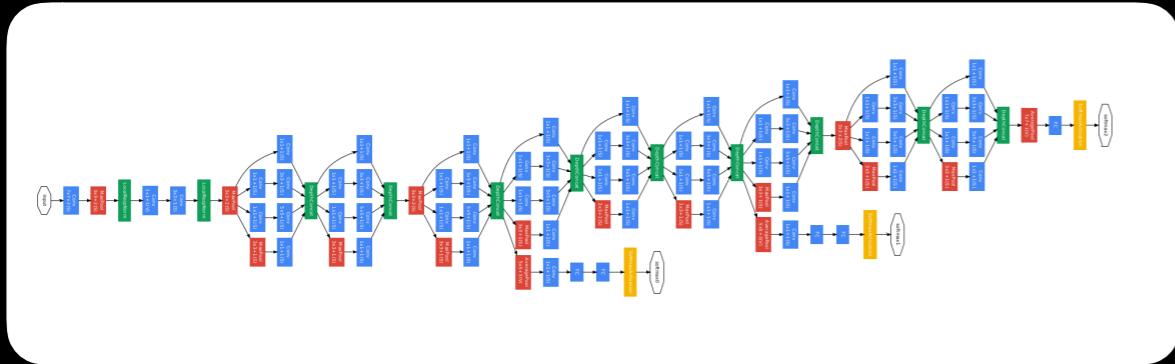
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Implementation



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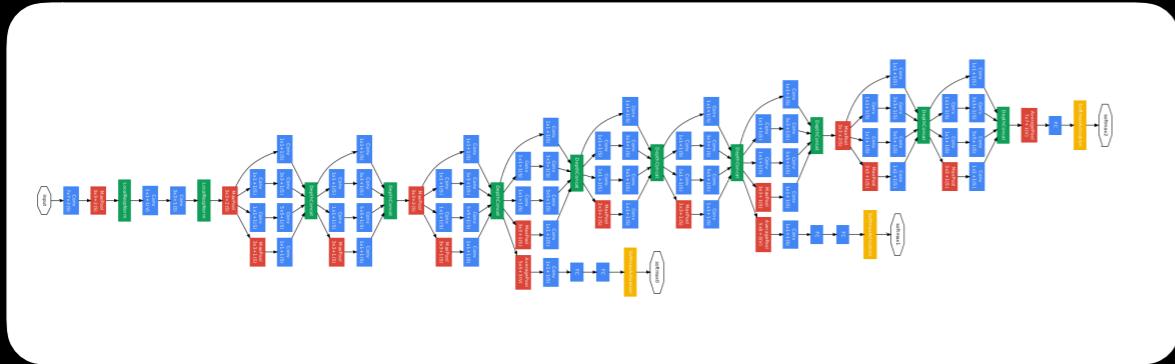
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Implementation



Caffe
Caffe2



CC



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Benefits for HUL



Robust, Real-Time, Accurate Object Detection and Tracking

Tracking with Memory and Robustness Against Occlusion

Same Highly Generalisable Architectures for ALL 30 of HUL's Factories

Cheaply Available Training Data, Open-Sourced Pre-Trained Weights



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DEMO!!



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QUESTIONS??



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A large, colorful word cloud centered around the words "thank you" in various languages. The word "thank" is in blue and "you" is in black. Surrounding them are numerous other words in different scripts and colors, representing the same phrase in many global languages. The background is white, and the overall effect is a vibrant, international representation of gratitude.

